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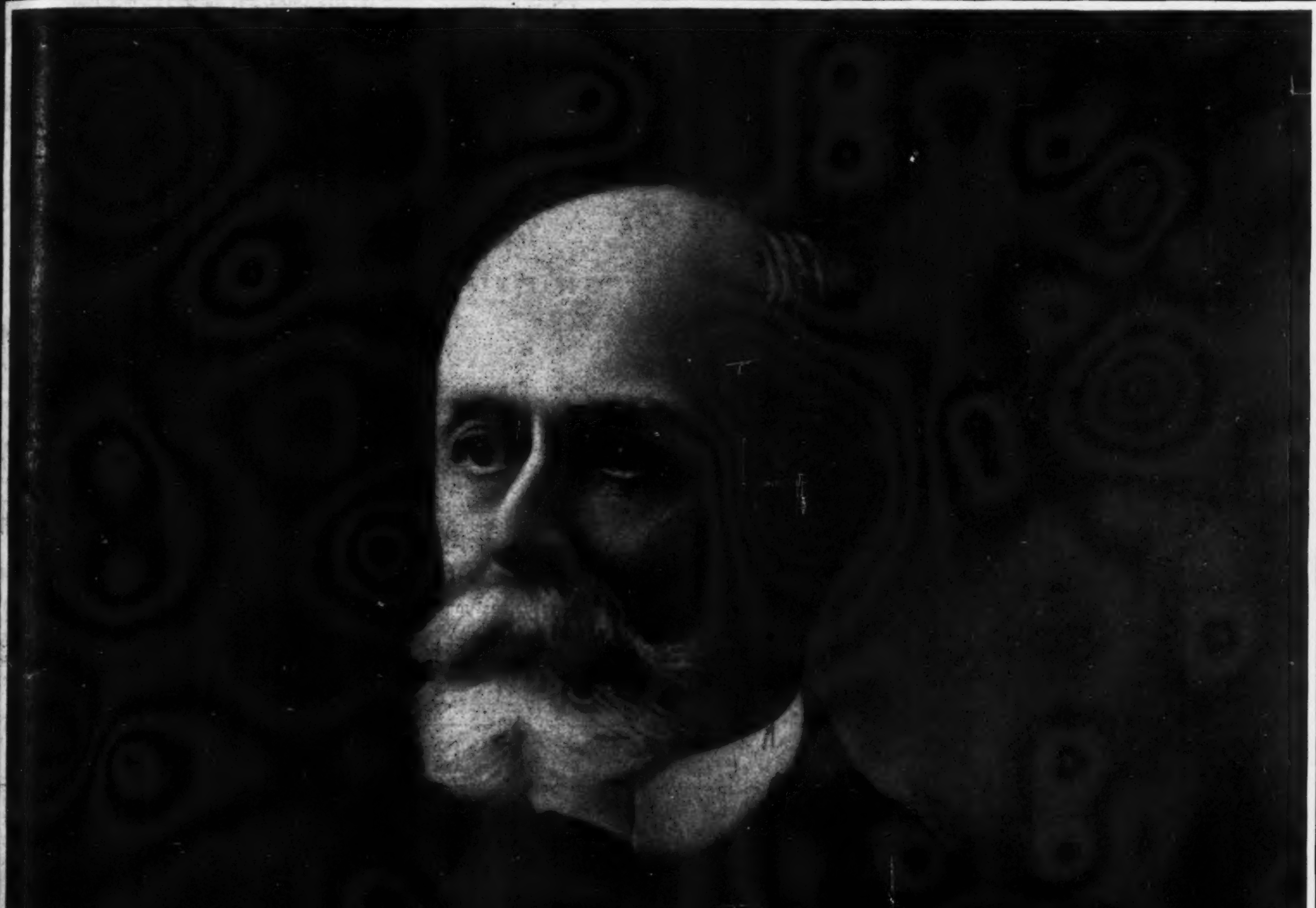


Henri Becquerel

HENRI BECQUEREL.

A DISTINGUISHED FRENCH PHYSICIST'S DEATH.

ANTOINE HENRI BECQUEREL, the well-known scientist, died in Paris on August 25 last.

Becquerel was born in Paris in 1852. He was educated at the Ecole Polytechnique and the Ecole des Ponts at Chaussées, graduating as an engineer in 1877. The next year he became professor of physics in the Museum of Natural History, where most of his investigations were carried on. In 1895 he held a similar post in the Ecole Polytechnique. He was admitted to the Institute in 1889. He received the decoration of the Legion of Honor in 1882. In 1903 he was one of the recipients of the Nobel prizes.

Becquerel was long considered one of the greatest of living physicists. He came of a line of distinguished men, his grandfather being the celebrated physicist Antoine César Becquerel, who died in Paris in 1878, and his father Alexandré Edmond Becquerel, who died in 1891, and who was a member of the Academy of Sciences and published among other things the results of some interesting researches dealing with the solar spectrum and with the constitution of electric light.

Antoine Henri Becquerel came prominently before the public in the years succeeding the discovery of the X-rays. His researches dealt mainly with optical subjects such as the rotation of polarized light by a magnetic field, phosphorescence, spectroscopic studies and the important and interesting invisible radiations from uranium. To these rays his name was given. It was in 1896 that he discovered them.

He was studying the action of X-rays on certain phosphorescent substances in causing them to emit a radiation which like the X-rays possessed the power of passing through substances opaque to ordinary light. He noticed the curious fact that in the case of uranium salts previous exposure to sunlight was unnecessary. He discovered that uranium salts were capable at all times of giving off radiations which would, like the X-rays, pass through ordinary opaque bodies and affect photographic plates. These rays, he discovered, also discharged electrified bodies in their neighborhood by ionization of the surrounding air. For his discovery of the Becquerel rays the scientist received the Rumford medal of the Royal Society of England. A more extended account of his work will be found in the current number of the SCIENTIFIC AMERICAN.

THE RIDDLE OF THE FOURTH DIMENSION.*

A SIMPLE EXPLANATION OF A DIFFICULT PROBLEM.

BY H. ADDINGTON BRUCE.

THE nature and meaning of the fourth dimension may best be made clear by the argument from analogy employed by its most recent exponents. Suppose a world in which space was not of three but merely of two dimensions—length and breadth. Such a world would be absolutely flat, as would its inhabitants. It might well be compared to a vast sheet of paper covered—to borrow the description given in his "Flatland" by Edwin Abbott, one of the most ingenious explorers of the fourth dimension—with a quantity of straight lines, triangles, squares, and other figures, which, instead of remaining fixed, move freely about, though without the power of rising above or sinking below the surface. The people of Flatland, to put the matter otherwise, would know absolutely nothing of upward or downward motion, would be compelled to move always on a dead level, would see each other only as lines; and, finally, would possess nothing of the quality known in our three-dimensional space as "solid"—although, to themselves, they would seem solid enough.

Similarly, if the Flatlanders dwelt in houses, their homes would be nothing more than open surfaces inclosed by lines, with swinging lines to take the place of doors. In order to imprison a Flatlander, it would thus be quite sufficient to draw an unbroken line around him. Not having the power of upward or downward motion, he could neither step over it nor burrow beneath it, and to him it would be fully as impassable as a stone or iron wall.

Now, even if this two-dimensional world were situated in the very midst of the three-dimensional space familiar to us, its people would ordinarily have no conception whatever of the larger space surrounding them. The latter would be, for all practical purposes, completely outside their universe and entirely invisible to them. Indeed, "upward" and "downward" and "height" and "depth" being terms that conveyed no meaning to their minds, they would be strongly inclined to deny the mere possibility of three-dimensional space, and would probably unite to suppress any rash individual that might assert its existence on the strength of some otherwise inexplicable experience. The only knowledge they could have of it would come from the intrusion of some inhabitant of the three-dimensional world into the plane on which they lived. And even then he would seem to them to be a supernatural being; or, if they disbelieved in the supernatural, would sorely perplex them as suggesting the need of sweeping changes in their long established notions of the universe.

Imagine for example the sensations of a Flatlander at the unexpected appearance of a three-dimensional man in his bed room. He had securely bolted the door before retiring; had made sure that no midnight marauder could gain entrance. Yet there, before his startled eyes, stood an uncouth and monstrous shape, different from any he ever had beheld before. The three-dimensional man would not, it is true, be seen by the astounded Flatlander in the form familiar to other three-dimensional men. And, at the slightest upward or downward motion, he would instantly vanish from sight. But so long as he remained on the same plane as the Flatlander, he would be visible, and would be recognized as other than a native of Flatland.

Most perplexing of all would be the question of how he gained admittance to the house. The Flatlander, having no idea that everything about him was open overhead, could not possibly appreciate the fact that the three-dimensional man had entered by the simple process of stepping across the lines that formed the walls of the house and of the bed room. And matters would not be much clearer to his limited understanding, if his visitor undertook to give him a concrete demonstration of the properties of the third dimension.

"You see," we may fancy the three-dimensional man explaining, "I am not obliged, like you, to move always on a level. I can go up or I can go down; and being able to go up and down I can easily step over the lines that seem to you to be solid walls, and also can look directly into this room, which you imagine is all inclosed but which is really open to the gaze and entrance of every three-dimensional being. The same is true of your cupboards, and bureaus, and everything else in which you store your valuables. They are nothing but open spaces, surrounded by lines. Why, even that safe in yonder corner in which you keep your money is accessible to me. I can reach into it and remove its contents without injuring the exterior in the slightest. No, I will not unlock it. I simply bend over, put down my hand, pick up your roll of bills—and there it is on the bed beside you."

Given the existence of a fourth dimension, it would be just as easy for a four-dimensional man to penetrate into a sealed box or chamber as it was for the three-dimensional man to enter the locked house in the supposititious two-dimensional world. And this for the reason that the four-dimensional man would possess a power of motion transcending any known in three-dimensional space, and at the same time would find all three-dimensional "solids" as easy of access as the line inclosed surfaces of a two-dimensional world would be to a three-dimensional man.

Everything in the three-dimensional world would be open to his inspection and entrance. He could, from his position in space, perceive all that was transpiring, indoors or out, in every quarter of the three-dimensional universe. Zöllner, the famous German astronomer and physicist, suggested as an explanation of the peculiar phenomenon known as clairvoyance, the possibility that the soul of the medium made an excursion into the realm of the fourth dimension, much as a man in a balloon ascends above a plain and obtains a view of everything happening on its surface.

The inhabitant of a four-dimensional world, again, could traverse every obstacle in our three-dimensional world with no more exertion than would be involved in stepping over an imaginary line. Just as the three-dimensional man, if thrown into the line-inclosed prison of the two-dimensional, might make his escape with the utmost ease, so would a four-dimensional being heartily laugh to scorn the bolts, bars, ceiling, and floor of a three-dimensional dungeon.

Without a moment's warning he might make his appearance in the midst of any assembly gathered behind closed doors; might startle a wakeful sleeper in the dead of night by visions as of a ghost; might help himself, at will, to all the treasures of our three-dimensional universe. Yet, unless he came exactly within the plane of our existence, he would be invisible, and to all intents and purposes non-existent to us. So that, lacking other than inferential knowledge of him and of his four-dimensional world, we should feel toward him and it very much as the imaginary two-dimensional man would feel toward the three-dimensional—that is to say, utterly incredulous.

Stranger still, in four-dimensional space the inanimate objects of our three-dimensional universe, as well as man himself, would, or could, undergo singular changes. "Were motion in the fourth dimension possible," to quote from Prof. Simon Newcomb, who deemed the subject of sufficient importance to discuss it in a presidential address before the American Mathematical Society, "an object moving in that dimension could be turned in such a way that on being brought back it would be obverted, or appear as in a looking glass. A man capable of such a motion would come back into our sight similarly obverted, his left side would now be his right, without any change having taken place in the relative positions of the particles of his body. The somersault he would have turned would have completely obverted every atom and molecule of his body without introducing any disturbance in its operations."

And in like manner with any three-dimensional object, however massive. The greatest of the pyramids, caught up into four-dimensional space, could be obverted with ease; while all hollow articles, like balls, gloves, etc., could be turned completely inside out without damage to the substance composing them. In such a case, a right-hand glove, for example, after being carried into the fourth dimension, would come back a left-hand glove, and *vice versa*.

The possibility of all this has been demonstrated by mathematicians with absolute exactness. But its actuality is quite another question. The great difficulty is to prove, or even to recognize, four-dimensional action. In fact, the prevailing view among scientists is that we must forever remain in the dark, owing to the limitation of our sense experiences. But there are those who hold to the contrary. Especially was this the case with the late Charles H. Hinton, who died in Washington last spring after many years devoted to four-dimensional investigation. Beginning with the idea of a two-dimensional world, Hinton worked out a scheme by which its inhabitants, despite their limited consciousness, could attain a conception of the third dimension; and by analogy he extended this to provide three-dimensional beings like ourselves with a means of recognizing the fourth dimension.

It became his conviction too that our space—three-dimensional space—had an infinitely small thickness in the fourth dimension, and that in this "thickness" was the field of atomic activity, with the atoms enjoying four-dimensional motion. In this connection might be mentioned the interesting circumstance that the alleged frequent and seemingly unaccountable disappearance of small objects from closed rooms is sometimes advanced in support of the theory of the fourth dimension; the idea being that in some mysterious manner they have rolled out of the plane of three-dimensional space, and hence have become invisible.

* The Tribune (Magazine Section).

PHYSICO-CHEMISTRY AND BIOLOGY.

THE RELATION OF ANIMATE TO INANIMATE MATTER.

BY ERNEST SOLVAY.

HITHERTO the physico-chemical side of the question of the synthesis of elementary organisms has been neglected, probably because it has been divined that physico-chemistry must undergo a transformation before it can be extended to the phenomena of life.

The object of this article is to present some novel ideas suggested by the experiments of Myers, Dixon, Baker, Lebeau, and others, and to formulate the general principles which distinguish absolute physico-chemical reactions between absolutely pure substances from thermo-catalytic reactions effected by an organization which is developed under the influence of foreign bodies.

Myers has discovered the incombustibility of carbon in dry oxygen, Dixon has shown that a mixture of carbon monoxide and oxygen loses its inflammability on being dried over phosphoric anhydride, and Baker has collated numerous examples of reactions retarded or entirely prevented by the absence of moisture. In particular, Baker and Lebeau have proved that absolutely dry hydrogen and oxygen combine only at a temperature nearly as high as the melting point of platinum.

The interpretation of these facts, in accordance with my theory of the continuity of normal physico-chemical reactions, leads to the following principles:

1. Two gases which are absolutely pure, chemically and physically, combine only at the temperature of dissociation of the resulting compound, at the given pressure.

2. This principle may be extended to all chemical combinations in the sense that for absolutely pure substances the temperatures of combination and of dissociation are identical. I call this point the "true" temperature of the compound.

3. For any given pressure there is a "true" temperature of combination and dissociation, as there is a "true" temperature of evaporation and condensation (the boiling point) and a "true" temperature of fusion and solidification. These temperatures form the sufficient and necessary conditions for the total accomplishment of the corresponding changes and they are also the highest temperatures at which these changes can regularly take place at the given pressure.

4. Any tendency to or commencement of dissociation or combination, or of change of physical state, below the "true" temperature of the change in question must be due to the presence of foreign bodies, which I call "thermo-catalyzers" because the essential result of their presence is an apparent lowering of the "true" temperature. There is no evidence of the existence of substances which raise temperatures of combination, dissociation, ebullition, etc.

5. Hence thermo-catalysis, like most other phenomena, involves a degradation of energy. Animal life, if we regard it (as I do) as an oxidation of carbon under conditions of maximum thermo-catalysis, offers an extreme example of this degradation, for the oxidation is effected at a temperature below 100 deg. F., while the "true" temperature of this reaction is supposed to be about 5,400 deg. F.

According to the views expressed above, thermo-catalysis is a physical process which is very different from the mechanical process which is commonly understood by the term catalysis. Everything goes on as if the energy which is necessarily disengaged when the reaction takes place at its "true" temperature (for all reactions occurring at their "true" temperatures are exothermic) appeared at the lower temperature in an electrical form at first, made a way for itself through the catalyzer, which serves to close the circuit, and was thus degraded and converted into heat. The name odogenesis, or "path making," has been given to this automatic construction of an electric circuit. The degradation thus effected electrically corresponds exactly with the thermal degradation which is represented by the lowering of the temperature below the "true" temperature of the reaction.

It should be observed that some foreign bodies modify the field of a reaction by increasing the area of contact of the two substances, or the rate at which that area is renewed, by promoting diffusion or circulation. In this mechanical acceleration of the reaction there is no odogenesis, and the substances which produce it, though commonly called catalyzers, are quite distinct from the thermo-catalyzers which we are considering and for which "degraders" would be a more appropriate name.

Furthermore, absolutely inert substances may act as thermostats and lower the temperature by absorbing heat. Here, again, notwithstanding the lowering of temperature, there is no odogenesis, and these bodies must not be confounded with thermo-catalyzers, although most of the latter also exert a thermostatic effect.

The double conception of an absolute physico-chemistry, confined to reactions occurring at their "true" temperatures, and a thermo-catalytic physico-chemistry, treating of reactions modified by thermo-catalysis, flows necessarily from the preceding considerations.

All absolute physico-chemical reactions must be vigorously reversible, for at the "true" reaction temperature combination, solidification or condensation of vapor occurs if heat is abstracted, and dissociation, fusion or vaporization takes place if heat is added. Thermo-catalytic reactions, on the other hand, are not necessarily reversible. For example, reversibility is impossible in certain reactions of organic substances, where thermo-catalysis is accompanied by so great an increase in the complexity of the mass that the stability of the compounds formed is incompatible with an elevation of temperature without increase of pressure.

The principle of thermo-catalysis, which is derived from the principle of degradation of energy, suggests that the substances which act as thermo-catalyzers, or degraders, need not be either foreign to the reaction or very small in quantity, as the current theory of catalysis assumes. A compound in process of formation, or its components, may exert a thermo-catalytic as well as a thermostatic influence upon another combination which takes place simultaneously with or subsequently to the first combination.

It is not unlikely that successive repetitions of this process may result in the formation of a series of compounds, susceptible of dissociation by a reversal of the process, the necessary condition being that each particular compound must be dissociated at the pressure at which it was formed.

The constituents of alloys and of liquid mixtures thus act as "auto-degraders" and lower the temperatures of fusion and vaporization respectively.

The problem of catalysis might have been attacked in another way. If we had simply proposed to maintain, in a catalytic reaction, the velocity proper to the same reaction unaided by catalysis, we should have found it necessary to lower the temperature, and thus we should have recognized the essentially degrading character of catalysis. We should have found, likewise, that a definite decrease in temperature would prevent the catalytic decomposition of any given compound by destroying the possibility of odogenesis.

The great retardation of physico-chemical processes —evaporation, for example—which can be effected by the employment of perfectly pure substances, proves nothing against the existence of "true" temperatures corresponding to those processes. From the viewpoint of absolute physico-chemistry, indeed, the usual conditions of reactions appear abnormal. Every physico-chemical reaction involves energy and, consequently, time. Its accomplishment under normal conditions implies a continuity which is not usually realized and involves the consideration of force rather than that of work.

It follows that the reaction must be regulated or organized in order to become continuous and normal, so that it can go on indefinitely at a constant rate. This normal organization requires a continuous supply and removal both of material and of energy. The absence of this makes possible the accomplishment of ebullition, for example, above its "true" temperature. Continuity, like the presence of thermo-catalyzers or degraders, would prevent this abnormal and accidental elevation of temperature.

The degradation or fall of temperature caused by thermo-catalysis appears to be necessary to the formation of very complex and unstable molecules. The great degradation which results in the formation of living tissue and the combustion of carbon at 100 deg. F. instead of 5,400 deg. F. cannot be effected by thermo-catalysis applied to purely chemical reactions between substances in definite proportions, because the number of available chemical thermo-catalyzers is far too small. It is necessary to invoke the aid of colloidal thermo-catalyzers, and it is worthy of remark that colloids are peculiarly sensitive to the electrostatic forces which necessarily accompany thermo-catalysis.

Carbon, in its successive higher combinations ending with protein, represents the thermo-catalytic medium, both chemical and colloidal, which is best adapted to develop self-organizing reactions, for a continuous supply and removal of material is possible only in media of extreme complexity. The entrance of a highly oxidizable germ into such a medium starts the process of oxidation and the electrical forces thereby set at work enable the cell to assimilate from the medium the materials required by its several parts. This power of "selectrolysis," as I have called it, is simply the consequence of the electrical conditions of the elements involved. The elementary organism thus engendered acts thenceforth, in its continuous and simultaneous growth and decay, as a transformer which automatically degrades the potential energy of the elements of the reaction.

The extreme complexity postulated above may apparently be attained by combinations of very diverse elements. It appears probable:

1. That to every chemical compound corresponds an elementary organism, which may or may not be realizable under appropriate conditions of pressure and temperature and which contains this compound in small but definite proportion.

2. That the number of possible organic types is, therefore, incalculably great.

3. That every thermo-catalyzer is a possible agent of self-organization.

4. That carbon and oxygen play the chief parts in these phenomena.

These extreme generalizations, which are merely a development of theoretical views which I have already expressed,* are strikingly confirmed by the recent researches of Kossel and Fischer on the nature of albuminoids. Fischer has shown that these bodies are built up of a great number of atomic groups, most of which occur more than once in the albuminoid molecule, and that the various albuminoids, from the simplest to the most complex, form a series which may fairly be called evolutionary. Analysis of the compounds of these groups reveals the characters indicated in my early speculations as those of vital reactions, showing the colloidal nature of the protamic nucleus and the proteids, their instability and their faculty of acquiring and losing definite properties, as well as the tendency of albuminoids in general and the protamic nucleus in particular to take up certain elements and form non-ionized combinations with them and to reject other elements and atomic groups. These facts strongly corroborate my views concerning "selectrolysis" and the evolutionary character of organized reactions. The protamic nucleus—the first manifestation of life—appears to be the real nucleus of vital structure, for it possesses the power of combining to form more complex molecules and of accomplishing an infinite differentiation of properties.

In general, the most recent experimental researches appear to justify the theoretical views which I first expressed in 1893.—Condensed for the SCIENTIFIC AMERICAN SUPPLEMENT from Revue Générale des Sciences pures et appliquées.

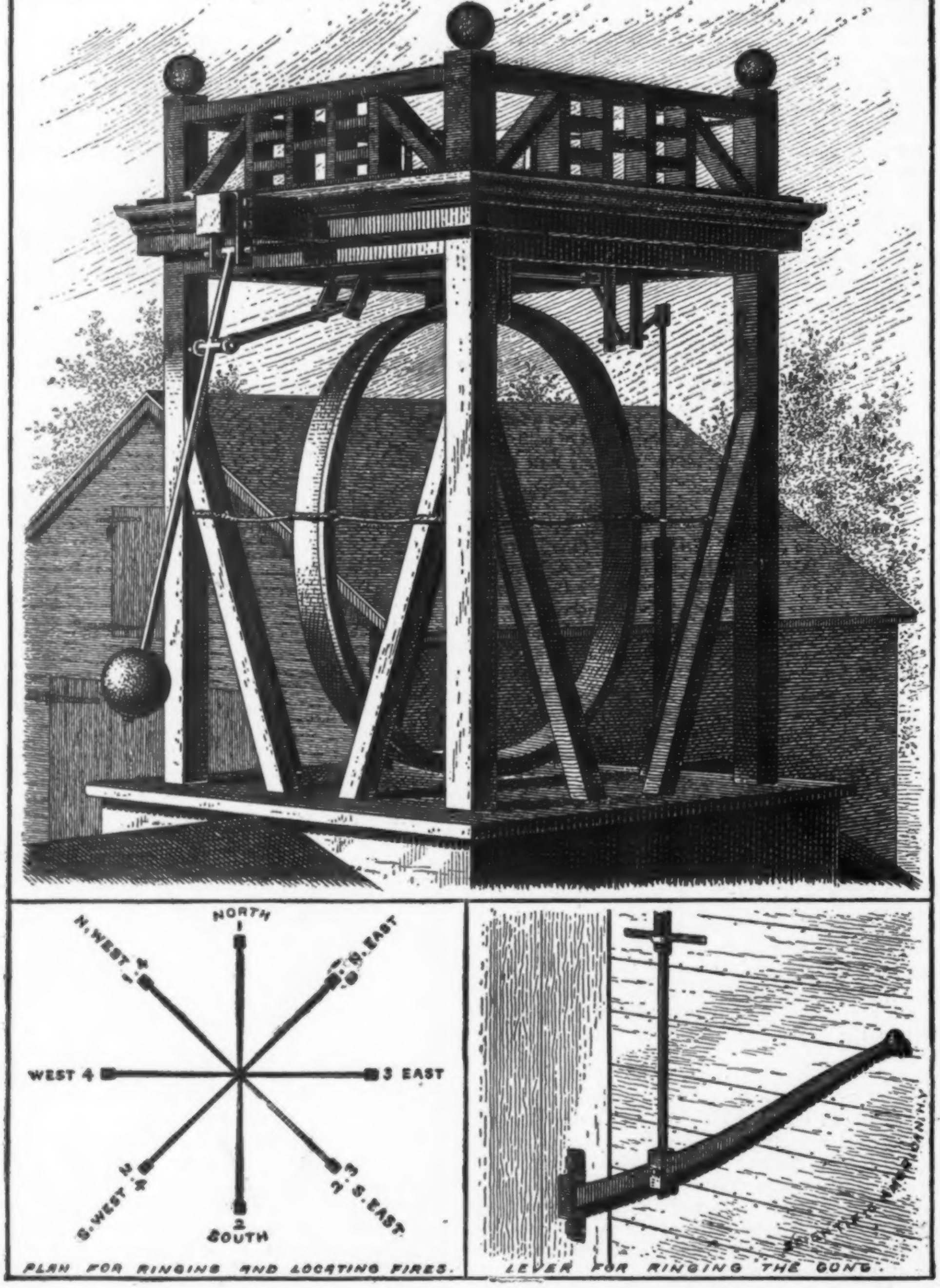
According to ideas generally prevalent, gases have a density far smaller than that of even the lightest liquid. In fact, the density of a gas has not so far been sufficiently increased by compression or cooling to exceed that of a liquid in contact with which it may be placed, it being supposed that the gas is neither liquified nor dissolved in the liquid. A memoir recently published in Archives Néerlandaises by Dr. Kammerlingh Onnes describes a rather striking experiment in which a bubble of compressed helium was caused to descend in liquid hydrogen, as a drop of water descends in oil. A mixture of hydrogen and helium was compressed in a capillary tube dipped into the liquid hydrogen. At a pressure of less than 49 atmospheres the hydrogen was confined to the bottom of the tube, and liquefied nearly entirely. Beyond that pressure a bubble of practically pure helium (which at the beginning had been floating at the surface) was seen to descend to the bottom of the liquid, and did not rise unless the pressure was reduced to 32 atmospheres, its volume being controlled by the Mariotte law. Apart from its originality, this experiment deserves special interest, allowing as it does the co-volume as well as the density limit (quotient of molecular weight by the co-volume) to be determined, which latter, according to theory, would equal that of heavy metals.

* "Du rôle de l'électricité dans les phénomènes de la vie animale" Bruxelles, 1893.

AN ECONOMICAL FIRE ALARM.

A SUGGESTION FOR VILLAGES.

THE present illustration is taken from the fire alarm at Boiling Springs, opposite Rutherford, N. J. The machinery for striking the gong or ring was made by a blacksmith of the town. The gong is held up in place by means of a ⅝-inch wire rope which goes around the gong and over a heavy piece of timber at the top of the tower. The striking apparatus with bearings are also connected to this piece of timber. These bearings are made of 2 x ½ bar iron and the striking material mostly of ⅝-inch round iron. The L-shaped bell crank with shaft is forged in one piece. The lower section of bell crank and the lever below are joined together by means of a piece of ⅝-inch round iron with a forked connection at the top and bottom. This piece of iron runs through a piece of gas pipe which is bolted to the floor as a support. One end of the lever works inside of a yoke which is bolted to the side of building. To throw the clapper or ball back the lever is drawn upward, which throws the upright part of the crank with forked connection backward, which in turn forces back the clapper. By pushing the lever down the clapper strikes the gong. The gong is a 6-foot tire of a driving wheel of a locomotive, is 1¾ inches in thickness, 6 inches in width and weighs 500 pounds. It yields a deep tone like a bell. On a still night it can be heard about two miles. The clapper weighs about forty pounds. A plan has been adopted for locating the direction of fires by strokes of the gong. One stroke indicates that the fire is in the northern section of the town. Two strokes, south. Three strokes, east. Four strokes, west. One stroke and a pause and then three strokes, indicates a fire in the northeast. Two and three strokes, southeast. One and four strokes, northwest. Two and four strokes, southwest. This fire alarm has been very satisfactory, costing, with gong and machinery, with labor, the small sum of $25.



LOCOMOTIVE TIRE USED AS A FIRE ALARM BELL.

THE BELLINI-TOSI DIRECTIVE SYSTEM OF WIRELESS TELEGRAPHY.

ATTENTION should be directed to a paper read before the last meeting of the Physical Society in which Messrs. Bellini and Tosi deal with experiments on a directive system of wireless telegraphy. The authors describe the results obtained in the course of their work upon a further development of their original directive system. In the earlier method it was not possible to say from which side of the receiving station the transmitted waves arrived, for though the radiation was practically confined to the plane of the aerial system, it was emitted equally in the opposite direction to that desired. In the new unilateral system the waves are sent in a single direction only, and the problem of getting rid of the backwardly extending radiation has thus been solved. The method adopted consists in superposing a bilateral directive system, as previously described, upon an ordinary or vertical antenna system. Since the two half-diagrams of the directive aerial are opposed in phase, it follows that when the two systems (directive and vertical antenna) are simultaneously excited and in phase, the one-half of the directed radiation will add itself to, and the other half subtract itself from, the radiation due to the vertical antenna system. The diagram of the vertical antenna system being a circle, the resultant diagram of the superposed systems will, for the case where these are in phase as regards excitation, be a cardioid whose maximum radius vector is double that of the diagram of the directive system alone. Since then the directive system is able to vary the direction of its maximum emission by means of the radiogoniometer, it follows that by moving the position of this latter it is possible to shift the direction of the resultant emission represented by the cardioid, in a corresponding manner. Several energy diagrams obtained by means of the thermo-galvanometer are reproduced in the paper, and these show that, even where the excitations are not exactly in phase, the only result is a slightly less good diagram. Diagrams of the scheme of connections employed during the taking of the energy diagrams are also given. The same principle of the superposition of the two systems has been applied to the case of the reception. In this case a phase displacement of 90 deg. in the excitations is produced in a suitable manner and in this way, when the pointer of the radiogoniometer is directed, say, toward the transmitting station, the reception is a maximum, while when turned at 180 deg. from this it is a minimum, or zero. Diagrams of received energy and of the connections employed, are given in detail. The system of unilateral directive wireless telegraphy described in the present paper is of special interest, owing to the facility with which it is possible to change over from one system to the other, thus, from the ordinary vertical antenna system to the bilateral directive or the unilateral directive, or *vice versa*. The aerial arrangements, moreover, remain exceedingly simple. When a message from a station of unknown position is expected, the vertical antenna or ordinary system would be employed.

On once effecting reception, one can pass to the bilateral or unilateral directive system and thus determine the direction and on which side the transmitting station lies, at the same time making one's self independent of other transmissions. In the same way, with the transmission, the vertical antenna would be employed for calling up an unknown station or for simultaneously sending to several stations; on once getting a reply the operator can then readily determine the position of the receiving station, with the aid of the unilateral system, and thenceforth will transmit solely in that direction. Attention is called to the advantages which such a directive system offers in the case of the commercial services as well as for military and naval purposes.

In the discussion that followed Dr. Fleming said that he had long been acquainted with the interesting experiments of the authors of this paper, and desired to express his congratulations on the skill and inventiveness with which these investigations had been prosecuted. He was glad to see that the experiments of the authors confirmed in many ways the theory which he (Dr. Fleming) had given of the operation of a bent antenna as employed by Mr. Marconi. When Mr. Marconi read his paper at the Royal Society in March, 1906, describing his experiments on directive telegraphy, he gave no theory in the matter, but Dr. Larmor pointed out in the discussion that an antenna partly vertical and partly horizontal was equivalent to the sum of a magnetic oscillator and an electric oscillator, and shortly afterward he (Dr. Fleming) had gone more carefully into the matter mathematically and showed that the observed effects could be accounted for on this theory. Both Mr. Marconi and he himself had obtained by the same methods as those employed by Messrs. Bellini and Tosi the same type of pear-shaped radiation curves obtained by the authors of the paper by combining together the effect of closed and open oscillators. Although this theory had been criticised by Dr. Mandelstan lately, yet nevertheless there did not seem sufficient grounds for objecting to it. Mr. Marconi had, as everyone knew, employed directive antennæ for a long time past in his power stations at Poldhu and Clifden, and had also given demonstrations showing that the position of ships out of sight could be located by means of such receiving directing antennæ. Nevertheless, Messrs. Bellini and Tosi had worked out extremely ingenious arrangements for determining the direction of the radiant point without moving the antennæ

themselves. He (Dr. Fleming) had also shown that, having the power to locate the radiant point, two stations equipped with such antennæ at a known distance apart could by simultaneous observations determine also the distance of the radiant point, and this might become important in connection with marine work. It ought also to be noticed that Dr. F. Braun, of Strasburg, had by the employment of three open antennæ having oscillations in them of definite phase difference, been able to obtain radiation curves having the form of a cardioid similar to some of those given by the authors of the paper.

THE WRECK OF THE "ZEPPELIN IV."

WHY THE GREAT CRAFT WAS DESTROYED.

THE "Zeppelin IV," Count von Zeppelin's latest and greatest airship, was wrecked in a thunderstorm while anchored to the earth near Stuttgart, Germany, on the 5th ultimo. The disaster occurred at the end of a lengthy journey, during which the huge dirigible thoroughly demonstrated its capability of traveling long distances at high speed, and also after it had twice landed safely upon terra firma, a feat which believers in the flexible gasbag type of dirigible thought it was unable to accomplish.

Shortly after the completion of its 220-mile 12-hour flight from Lake Constance to Lake Lucerne, as described in previous issues of this journal, the Zeppelin airship "No. IV," was considerably damaged by being blown against the side of its floating shed when it was being towed out, and about a fortnight was spent in effecting repairs. On August 4, at 6:30 A. M., Count Zeppelin made his final attempt at accomplishing the 500-mile, 24-hour journey required by the German government before it would purchase the airship. The weather was propitious, and the huge air vessel made another record-breaking flight. Its objective point was Mayence, on the Rhine; and accordingly the course followed was westerly along this river to Schaffhausen and Basle and then northerly above it. About nine hours after it started, the airship descended upon an island in the Rhine at Oppenheim, some eight miles from its destination. The distance covered was about 260 miles, so that an average of 29 miles an hour had been maintained, despite the fact that the airship had stopped to perform evolutions above some of the cities it passed over. Several hours were spent in repairing the driving mechanism of one of the four propellers, and finally, about 9 P. M., the huge air craft reascended, and 1½ hours later was seen above Mayence. It started at once upon the return journey, but the 110-horse-power motor in the forward car gave trouble, thus making it impossible to travel at more than half speed. During the night, the airship was sent to an elevation of 6,000 feet, and the loss of gas occasioned by this maneuver made it necessary to land. The airship alighted without trouble at Echterdingen, near Stuttgart, and some 75 miles from Friedrichshaven, about noon on August 5, and its navigator telegraphed for extra cylinders of gas, and set his mechanics at work repairing the motor. The airship was anchored in a large field, and was guarded by a detachment of soldiers. While Count Zeppelin was at lunch at a nearby inn, a storm suddenly arose and buffeted the airship so heavily that it broke away, floated up to a height of about 500 feet, and burst. The hydrogen ignited in some mysterious manner, and the colossal airship was quickly destroyed. It drifted half a mile from the place where it was anchored. All that remained after the catastrophe is shown in one of our photographs.

The dimensions of the wrecked balloon have not been given out officially. According to a nephew of the Count, the actual ship has a length of 135 meters (443 feet) and a diameter of 13 meters (42½ feet), and is fitted with two 110-horse-power Daimler motors. It is probable that the projected area in a longitudinal vertical plane, if we include the supporting framework, the engines, propellers, and working platform, was not far short of 18,000 square feet. The ship is thus larger and more powerful than the last model. The two gondolas, each 26 feet in length, were connected by a gallery, on which accommodation was provided for the passengers. The motors were mounted in the gondolas; each motor drove two propellers, fixed fore and aft off the lower portion of the balloon. The flooring of the gondolas partly consisted of celluloid.

The seventeen compartments of the airship contained 13,000 cubic meters (141,240 cubic feet) of hydrogen gas, which gave a total lifting power of 14,300 kilos (31,460 pounds). Of this only 5,000 kilos (11,000 pounds) represented the weight of fuel, passengers, and freight. In other words, 9,300 kilos (20,460 pounds) represented the dead weight of the craft itself, a weight which had to be lifted and propelled over and above the weight of passengers, fuel, and freight.

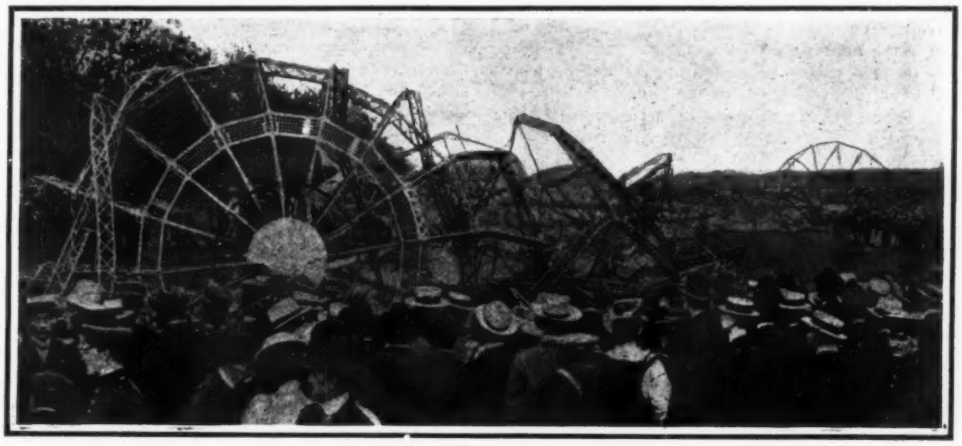
The two 110-horse-power Daimler motors were far from economical. Their gasoline consumption, even on a basis of 0.45 liter per horse-power per hour, was roughly 100 liters, or 22 gallons, per hour for the 220 horse-power of the engines. For ten hours something like 220 gallons were consumed, representing a weight of 700 kilogrammes (1,540 pounds), not including the weight of the gasoline containers.

Each inflation of the seventeen compartments of the gasbag represented an expenditure of $1,400. Considering the expense incurred each time the airship was taken out of its shed (costly because of the personnel required), and the great cost of the entire structure itself, it is evident that the capital invested must have been enormous. A French aeronautical engineer calls attention to the fact that in order to drive the airship at a speed slightly in excess of that made by the French dirigibles, ten times as much money had to be spent. Naturally, he asks if the game is worth the candle.

Although it has for years been our conviction that, because of the great area which it exposes to the wind, the dirigible balloon is at its best a precarious means of air navigation, we have always appreciated the intelligence and courage with which Count Zeppelin has persevered in his attempts to bring the practical out of the impractical. His recent misfortune is not to be set down to any lack of skill or forethought on his part; it is due rather to certain fundamental principles, which govern the whole theory of the dirigible balloon—principles which, like sunken rocks at sea, are an ever-present menace, and are liable to wreck the ship of the air with the swift and unheralded destruction which marks so many marine disasters.

The very size and bulk which give to the airship its undoubted advantages of buoyancy, steadiness, and lifting power, expose this type to almost certain destruction, should it be struck by a sudden squall when it is anchored near the earth. Moreover, it is by no means certain that the dirigible, though constructed with the skill shown by Count Zeppelin in his latest airship, would be able, even if far above the earth, to stand the wrenching and twisting stresses, and the fierce vortices, which are liable to occur in a heavy windstorm.

Engineers, in determining wind stresses to which bridges and tall buildings are exposed, adopt a maximum of 30 pounds to the square foot as representing the average pressure in a heavy wind storm over a large surface. The strength of the first rush of wind in a thunder storm, such as that which wrecked the Zeppelin airship, might possibly be sufficient to reach the 30-pound unit pressure, in which case the whole structure would be subjected to a broadside pressure of over 250 tons. End-on, the pressure would not be much less than 28 tons on the projected area. But even in a moderate breeze, the area is so great that the side pressure would easily amount to from 20 to 30 tons. It is evident at once that, under such conditions, the balloon, if anchored, must necessarily be swung over and dashed against the ground; and that, when in the air, even if it possessed sufficient strength to resist the distorting strains of uneven and fierce air blasts, there would be no alternative but to be blown before the gale.



THE END OF THE ZEPPELIN AIRSHIP.

The craft was anchored at one end and tossed about by a violent wind. One of the hydrogen compartments exploded and the remaining compartments were immediately ignited.

THE ZEPPELIN AIRSHIP A FEW MINUTES BEFORE THE ACCIDENT.

The craft had alighted at Echterdingen during its twenty-four trial.

THE ZEPPELIN AIRSHIP DISASTER.

GALVANIZING.—II.

SOME PRACTICAL SUGGESTIONS.

THE GALVANIZING OF IRON WIRE.

GALVANIZED iron wire has the excellent property of not rusting in the air, and can therefore be used with great advantage for fastening, for fencing, and especially to take the place of the expensive copper wire for telegraph lines.

To prepare galvanized wire, a work not requiring special care, the wire, wound into rolls, is pickled in dilute sulphuric acid, the rolls are then laid into the zinc bath, shaken violently several times after removal, to get rid of the superfluous zinc, and cooled in water. It is evident that this process will not give wire of very fine appearance; the latter can be improved by passing the wire, after galvanizing, through a wire-drawing plate, of the same number as the one used for the wire before galvanizing. The zinc coating is by this means pressed firmly on to the iron; but it is of importance to heat the wire to about 120 deg. C. before putting through the plate, as otherwise the coating would not be sufficiently pliant and would crack.

A better method, and one giving a much more uniform product, is the one in which the wire is pickled perfectly bright and then removed from the cylinder on which it has been wound and put through a zinc bath; but in order that the galvanizing may be properly done, it must be carried through the bath with a certain rapidity, which is to be ascertained by experiment.

Still another method, by which iron wire can be very finely galvanized, is as follows: The wire is rolled on a drum in parallel layers, so that it can be easily unwound; and the axle of the drum is checked so that the wire can be drawn off only by exercise of a certain amount of force. In front of the drum is a narrow wooden vessel several yards in length, containing the dilute sulphuric acid in which the wire is pickled. At the side of this trough is another of the same form, with water for the superficial rinsing of the pickled wire. A third trough contains a blue vitriol solution, consisting of one part of vitriol to ten of water, and in a fourth is a solution of one part of sal-ammoniac in ten of water.

The wire is pickled in the first trough, rinsed in the second, in the third covered with a very thin layer of copper, and in the fourth covered with sal-ammoniac solution. It is finally put into the galvanizing vessel, a trough whose sides incline toward each other and which is heated only on one side. This is an American invention, and has the purpose of letting the iron and zinc alloy, which is formed after long continued use of the bath, sink to the bottom, so that the bath can be used longer. The wire, when taken out of the zinc bath, is passed through a vessel of boiling water, several yards in length, then put through a wire-drawing plate, and rolled on a drum, as a finished product.

In the American method of galvanizing wire for telegraph wire, the wire is put through an oven before pickling, then pickled in an acid bath and put directly into the zinc bath.

In either one of the above-described processes, the principal point is to find just the right degree of rapidity with which the wire should be passed through the pickling fluid and through the zinc bath.

As the points where galvanized wires are joined by knotting together are liable to be exposed to rust by the breaking of the coating of zinc, it is well to dip the knotted wires in a small vessel of melted zinc, on which chloride of zinc is floating; a coating of zinc will thereby be formed over the knots which will protect the metal.

GALVANIZING SMALL OBJECTS.

To galvanize small iron articles, such as chains, rings, hooks, and nails, thereby protecting them from rust, they are first put into a vessel containing dilute sulphuric acid, in order to pickle them bright, then dried, and put into the melted zinc. The usual method is to lay the articles into a net or basket of strong wire, and to immerse this in the melted metal, shaking it around to make sure that all the pieces come in contact with the zinc. After remaining two or three minutes in the zinc bath, they are removed and thrown into a little flame-oven, covered with powdered coal and brought to a red heat. The excess of zinc is hereby melted off, and collects in the lowest parts of the bottom of the oven. The articles are then drawn with rakes into the higher portions of the oven, moved around until the zinc coating has hardened, and the adhering coal powder is then rubbed off.

The zinc coatings on small articles are more durable if the objects are first lightly copper-plated before galvanizing. The simplest way of doing this is to put them, after pickling, into a trough and pour over them a solution of one part of blue vitriol to ten of water; after having remained a few moments in contact with the fluid, they are removed, rinsed and thrown into the zinc bath. The thickness of the zinc coating varies according to the time during which the objects are left in contact with the fluid zinc; experiments have shown that in the case of galvanized sheet iron, the thickness of the layer varies from 0.006 to 0.043 millimeter, which corresponds to 45-300 gramme of zinc per square meter of surface.

THE ELECTROLYTIC METHOD OF GALVANIZING IRON.

Perfectly bright iron, dipped in a solution of zinc vitriol, and exposed to a strong electrical current, becomes quickly coated over with pure zinc. The coating, however, is dull; to give the usual luster of zinc, the sheets are quickly heated to the melting point of zinc, cooled, and passed between smooth rollers.

GALVANIZING BRASS, BRONZE, AND COPPER.

To give a coating of zinc to small brass, bronze, or copper articles, these can be dipped directly into melted zinc, after having first been made bright. But experience has shown that the zinc coating is finer and more durable if the objects are first given a light coating by the wet method before being galvanized by the hot method. They are first to be made perfectly bright by pickling and scouring with sand, then rinsed and laid into a box lined with sheet zinc, filled with a fluid prepared by dissolving in commercial hydrochloric acid as much zinc as it will hold. This fluid is a solution of chloride of zinc and a quantity of sal-ammoniac is now dissolved in it equal to the quantity of zinc used in the solution. The articles to be galvanized are left in the fluid one or two minutes, or until little bubbles of gas begin to rise, then dried by holding them over melted zinc, and finally dipped into it. They will quickly receive a uniform plating of zinc.

Another method is to lay the object into a porcelain vessel containing granulated zinc and a solution of sal-ammoniac, and to heat the vessel until the fluid is at the boiling point, when the objects are removed and immersed in the melted zinc.

In the case of small articles, the electrical method of galvanizing is frequently substituted for this one, since in the latter way it is possible to give the zinc coating any desired thickness, and also many objects can be galvanized at once.

In consideration of all the facts which have been adduced in the comparison of galvanized iron with tin-plated, there can be no doubt which is the better method in cases where the poisonous property of zinc need not be considered; in such cases galvanized iron has entirely superseded the tinned metal, and the latter, on account of its high price, is no longer used except for cooking utensils or similar fine tin work; for building purposes or for large vessels for holding water, either sheet zinc or galvanized sheet iron is employed, the latter having the advantage of far greater durability.—Translated from the German of Friedrich Hartmann in "Das Verzinnen, Verzinken, etc., der Metalle."

FREE LIME IN CEMENT.

DURING recent years there has been a very great advance in the manufacture of Portland cement. This is attributable to many causes, the chief of which are probably the gradual extension of the system of having tests made in regard to the quality of the cement by independent specialists; the greater appreciation by engineers of the requirements for making good concrete, and the influence of fine grinding; and, finally, the coming of reinforced concrete. These have resulted in a gradual increase in the stringency of specifications. Engineers have not rested satisfied, but have asked for a continual improvement in the strength and quality of cement. The placing of the testing in the hands of specialists who have standardized methods, has required the manufacturer to discard his old rule-of-thumb ways and to employ competent chemists to supervise the manufacture of Portland cement in every stage. In the early days of Portland cement manufacture there was risk of considerable quantities of free lime being present in the materials, due to the irregularity of proportioning and mixing and of the burning in the early type of chamber kiln, the effect of the latter being often to permit underburnt clinker to be ground up into the cement. This free lime and the presence of underburnt clinker caused the material to undergo considerable expansion in setting as well as frequently causing the work to be unsound. The special tests designed to insure constancy of volume, i. e., to eliminate expansion, were therefore gradually increased in severity, and the manufacturer was pressed to effect improvements in this direction. At the same time the influence of fine grinding set off in part the deleterious results due to the presence of free lime, especially when the cement was stored in thin layers so as to allow air slaking to take place—a general requirement in the early days that was the outcome of the presence of free lime due to underburnt clinker. The proportions of the materials entering into cement are ruled by chemical reactions, and therefore they are fairly settled, but, to produce a good cement, the materials require to be thoroughly vitrified at a high temperature in order to eliminate the presence of free lime. In the early days of manufacture, although the proportions of the lime might be chemically accurate enough to secure a proper cement, yet the silicates and aluminates of lime had not been formed by the reactions that required high temperatures, and consequently the lime present was quick, of the nature known as "free."

A good deal of cement continues to be manufactured in chamber kilns, and these have been improved, as also the methods of manufacture, so that a much better quality of cement is produced with them than was formerly the case; indeed, it was only necessary to exercise great care in the rejection of underburnt clinker to obtain good-quality cement from the earliest kilns. However, the last few years have seen a considerable change in the process of manufacture, for the rotary kiln, which had been experimented with for many years, has at last been brought to a state of perfection, and many cement manufacturers have adopted it because it economizes in manufacture as well as secures a better quality of cement. Underburnt clinker can of course be produced in the rotary kiln, but with ordinary care an almost perfect product results—that is to say, the vitrification of the materials is such as to combine the whole of the ingredients and leave no free lime present. The clinker obtained from such rotary kilns is very different from that from chamber kilns, being in small nodules, not in lumps. The quality of the cement to-day is measurably superior to that of the early cements; yet we hear complaints, and it is the purpose of this note to draw attention to certain characteristics which we think require careful investigation.

The Chatelier test for constancy of volume was of considerable value at one time, but too much importance has been attached to it. With the idea of practically eliminating expansion altogether, manufacturers have decreased the quantity of lime and have increased the quantity of alumina in the cement. A small proportion of free lime in cement may be present without material disadvantage, for many classes of work, particularly in building construction, for the adoption of reinforced concrete work has made it a more general custom to employ mechanical mixers and to use the concrete fairly wet, which are safeguards additional to that of fine grinding, because in this way the cement is more thoroughly incorporated throughout the mass, and the water penetrates into every part. Furthermore, the fineness of grinding means that any free lime particles are more intimately mixed throughout the cement. It has been the custom for a long time to depend upon tensile tests to ascertain the strength of cement, but these are practically of no value. We do not require Portland cement to develop great tensile strength; in almost all cases it is called upon to develop compressive resistance. Manufacturers have been making their cement to conform to tensile tests which are entirely opposed to practice. They should have discarded tensile tests altogether, rather than take the opposite view, as they have done. If they had watched closely the results of tests upon the compressive strength of their cements, they would have been able to greatly improve the quality of the cement for practical purposes far better than they have been able to do by elaborate work in other directions. A cement that has a proportion of alumina which is so great as to cause us to call it overclayed, may develop a high tensile resistance, but it will be deficient in regard to compressive resistance. Therefore, briquettes in a tensile testing machine may show good results, and tests as regards expansion by the Chatelier method may be excellent, but the cement may after all be very inferior. Even if a certain amount of expansion in the setting of Portland cement is residual, the means which go to counteract it, such as fine grinding, thorough mixing, and well wetting, will be taken up by the voids present in the concrete, but if the cement errs on the side of entire elimination of expansion or indeed contraction, certain effects result which may be very harmful in practice.

Architects and engineers were at one time much frightened at the possibility of concrete floors expanding and pushing the walls out, and we sometimes find in old specifications a requirement for a space to be left between the edges of a concrete floor and the walls to allow this expansion to take place. Though such expansion may have occurred in a few instances with very bad cement, and so may have led to these requirements being stipulated, as a general rule nothing of

the sort ever took place, and enormous areas of floors have been constructed without any provision in this respect, and no expansion has been noticeable. Thus manufacturers have been engaged in pursuing a shadow in trying to eliminate expansion, for the results in practice are not so harmful as they have been supposed. They have now gone too far, and we have lately heard of instances where overclayed cement was used for the construction of concrete floors, of contraction taking place in the setting, which drew the floor slabs away from the supports and caused cracks; obviously this is very detrimental. Many minor troubles that have occurred in connection with the cracking of concrete floors might be traced to this overclaying, if we may so call it of the cement, and the elimination of expansion. There are other aspects, also, of the results of contraction in concrete which may here be set forth, to be borne in mind by manufacturers.

In reinforced concrete work, steel is, as a rule, introduced for the purpose of taking tension, but it is also often introduced to reinforce the concrete in the resisting of compressive stresses—as, for instance, in columns, posts or pillars. The vertical rods in such structural members are imbedded sufficiently far within the concrete to feel the full effects of any contraction that may occur. This will put an internal compressive stress in the steel that may be considerable, so that in building a column under such conditions on ordinary theory, we may have the steel overstressed, to counteract which we ought in designing it to resist any specific load to increase its amount, which, of course, is not in the direction of economy. The same thing applies to the construction of reinforced concrete arches. In some few tests that have been conducted upon reinforced concrete beams it has been surprising to note that practically no deflection has taken place in the first stages of loading. An explanation of this, it has been suggested, may be found in the contraction of the concrete, which would introduce compression into the steel that would have to be neutralized by the application of loads before deflection under the tensile stresses thereby induced would become evident.—The Builders' Journal and Architectural Engineer.

APPLICATIONS OF OIL-BURNING APPARATUS.

A REVIEW OF PRESENT METHODS.

BY C. M. RIPLEY, E.E.

PERHAPS the most unique and unexpected application of oil-burning apparatus is in the heating of railway coaches on the electric divisions of steam railroads. The New York Central and New York, New Haven & Hartford railroads have both installed vertical steam boilers in the electric locomotives of their new equipment, and equipped them with oil burners, pressure tanks for oil and water, and utilized the compressed-air system of the train for atomizing the oil. Thus, as soon as the steam locomotive is detached from the passenger train, the electric motor can be coupled on, and the existing piping system of the train used to heat the cars. The expense of installing electric heaters in each car, the expense of power for these heaters, and the danger that would have resulted from coal stoves, are all dispensed with.

At the plant of the Pennsylvania Bridge Company, Beaver Falls, Pa., advantage has been taken of many of the latest devices to bring about economical production and fabrication. Among these is the installation of oil-burning furnaces for rivet heating, etc.

This equipment consists of a 10,000-gallon supply tank buried in the ground outside the building and near the railroad switch to facilitate the unloading of the oil cars. An oil pumping, heating, and pressure regulating system, located in the shop, draws the oil from the supply tank, strains it, and after raising the temperature to the proper point for complete combustion, pumps it to the burners under 20 pounds pressure. Compressed air for atomizing the oil is taken from the regular shop air line, and reduced by a regulating valve to 15 pounds before being piped to the burners. As only 150 cubic feet of free air compressed to 15 pounds are required under the system in question for each gallon of oil burned, the air taken for atomizing is hardly felt.

There are five double-door stationary rivet forges, with hearths 16 x 24 inches, and four similar in design but 12 x 18 inches, with the tank containing the oil supply located underneath, and connected with the air supply by a flexible hose. This last furnace is designed to allow of its being moved from place to place in the shop. All these furnaces are equipped with a burner so designed that there will always be perfect atomization of the oil, and also that the one lever regulates both oil and air supply.

The relative merits of oil, coal, and coke as fuel for the forge shop are ever open for discussion and experiment. The writer was recently allowed the favor of taking a trip through the factory of a well-known manufacturer of railroad cars, and was much interested in the operation of the oil-burning furnaces in the blacksmith shop.

There were seven furnaces, ranging in size from 36 x 18 inches up to practically twice that size. These were used for heating up king-pins, bar iron, etc., some to a bending temperature and others to white or welding heats. All were designed so that only enough compressed air was supplied to the burner to atomize the oil thoroughly, while the air for combustion was supplied by forced draft by a separate piping system. Thus the air for combustion is not drawn in from the surrounding air, which always makes a noisy burner, but is forced in under a few ounces pressure, at the rate of approximately 1,440 cubic feet of free air per gallon of oil.

The writer was privileged to view some work on a lot of kingpins. These were made from 2-inch billets about 20 inches long, and were heated for a distance of 12 inches from the end, at the rate of 21 pins in seven minutes, at the end of which time each was white hot and a ¾ x 2-inch slot was punched through in one operation.

It has been the writer's experience that where hard coal or coke was used in the forge, the time in tending fires and cleaning out the slag and cinders can be easily an item consuming more time than is usually believed. After witnessing the speed with which the bars, billets, and plates were heated, and the wide range of sizes taken care of, the conclusion was irresistible that for the same floor space the oil furnace could approximately double the output where high heats are required on work about 2 inches in diameter. Where only bending or swaging heats are required, I should conclude that there is easily a 50 per cent increase for equal floor space.

STEAM GENERATION BY OIL FUEL.

Starting the Fire.—Since the oil must be atomized, the initial starting of the fire requires either a supply of compressed air to turn into the atomizing nozzle until steam pressure has been attained (when it is switched off to steam by a threeway cock) or else a small boiler must be kept as an auxiliary. This disadvantage is made up in the fact that by starting the oil and throwing some oil-soaked waste into the firebox, the fire is instantly in full blast; this has been found to be a great time saver in the long run, for plants that close down entirely.

Kind of Oil to Use.—Oil with a fire test of 180 to 200 deg. F. is considered as safe as coal, which latter has been known to ignite spontaneously. If oil with a test of 250 or 300 deg. is stirred with a red-hot poker, it will not ignite, and even a shovelful of hot coals thrown on its surface will immediately sink and be extinguished. Crude petroleum or fuel oil is the commercial name.

Storage and Temperature of Oil.—The oil is best stored, when convenience and safety are both considered, in an underground tank between the railroad track and the boiler room. The most successful result is obtained when the oil fed to the burners under constant pressure is strained and heated before fed to the furnace. It might be mentioned here, however, that the piping into the breeching of the boilers is frequently so arranged that a considerable rise of temperature is obtained by the time the oil reaches the nozzle—sometimes as high as 200 deg. F.

Importance of Atomization.—As is the case with any fuel, oil must be thoroughly mixed with air in order to secure complete combustion and no smoke from the stack. If the spray of oil contains some small and some large particles of oil, the larger particles, being supplied no more air than the small ones, will not be burned, and the result will be a coating on the boiler tubes which is more difficult to remove than the soot deposited from a coal fire. This difficulty, however, has finally been entirely overcome by the latest design of nozzles, which give a steady fire and no smoke. In the Texas oil fields, where oil is especially cheap, and in California, where coal is especially dear, the results of a tour of inspection will convince anyone of the fact that burners have been obtained which are most efficient and satisfactory. The old-time explosions which occurred now and then were due to the fact that the oil dripped, and later evaporated till the mixture with air became explosive. This danger has been proved a dead issue, since many of the insurance companies are giving the same rate for boilers using oil as a fuel as for those using coal. Frequent tests with open flame, of boiler pits, and many months of successful operation have convinced the most skeptical that oil burners for steam boilers are practical, safe, and convenient attachments, even as auxiliary equipment. The best comparison to be made between oil burners of the present and of the past is the comparison between the Welsbach gas lamps of the present, that thoroughly mix the gas with the air, and the obsolete open tip, which is both inefficient and filthy.

TRIPLE USE OF OIL BURNERS IN STEEL MILLS.

Oil burners can be and are being employed in some of the greatest and most progressive steel mills in the country, in three capacities:

1. To heat the open hearth furnaces regularly.
2. To serve as auxiliary where gas is used.
3. To heat the ladles and prevent explosions and consequent loss.

For Continuous Use.—In the open-hearth process there has been proved a saving by the introduction of oil burners. This saving is made up by the following items, as gathered from talks with users:

a. A lower grade of scrap or a greater per cent of scrap can be used, since oil is comparatively free from phosphorus and sulphur.

b. Since the highest temperature of the oil flame is at the bottom, it follows that it is directly applied to the "bath" and not to the walls, arches, and doors of the furnace. It is the enthusiastic opinion of users that shutdowns for repairs to doors and brickwork are much less frequent; so much so that a run of 840 heats was made at the General Electric Company. The Midvale Steel Company and others report extremely satisfactory results also.

c. Owing to accurate control, the furnace can be banked for two or three days and then heated full blast in 12 to 16 hours, a thing impossible to do with a gas furnace.

d. Small first cost as compared with producer-gas systems.

e. Large saving in labor, since furnace attendants can take care of oil burner, while large corps of men are needed to operate producer-gas plants of any considerable size.

f. Efficiency has been as high as 38 gallons oil per net ton of charge.

As Auxiliary Equipment.—The oil burner is made hinged, so that it can be swung out of action until such time as the regular fuel supply might happen to fail. Thus it is ready at a moment's notice, and the heat of the bath and walls instantly brings the flame to an efficient state.

To Heat Metal Ladles.—The swinging stand or hinged idea is used here as in the open hearth auxiliary arrangement. Thus it can be lowered into the ladle, the long nozzle reaching clear to the bottom and thoroughly heating and drying the entire ladle.

OIL BURNERS IN THE BRASS FOUNDRY.

One of the largest electrical manufacturing companies in the country states that No. 70 Dixon crucibles, which lasted only 17 or 18 heats when coke was used as fuel, now last from 30 to 32 heats since the oil burners were installed in the foundry.

The same company states that the cost of fuel has been cut in half and that the annoyance, dirt, and expense of handling ashes has been entirely eliminated. It is interesting to note that although a brass foundry was originally built for coke, it can be easily piped for oil burners. One of the manufacturers of oil-burning apparatus offers the free service of their engineering department in designing the complete layout for any foundry, showing the application of the oil burners, if the owner will but submit a sketch of the present equipment.

The writer has been much interested in chatting with the various manufacturers who have adopted oil for a fuel, and was pleased to note the general satisfaction which follows its adoption. The quiet and unostentatious development of any line of enterprise often gains a far greater lead than is generally supposed. The author is glad to be able to present the various applications of this particular line of thought to the engineering public, i. e., the readers of this publication.

THE HOMES OF MEXICAN PEONS.

BY H. GURLITT.

GREAT indeed is the difference between the dwelling of the average American farmer and that of the peon of the *tierra caliente* or tropical region of old Mexico. Both build their habitations in accordance with local and climatic conditions, and often with the least possible expenditure of time and money. The last is unfailingly the case with the peon, whose very necessities often become actual luxuries, and who consequently adopts merely the most practical and essential devices, both in his building operations and in the furnishing of his abode. The peon's house is merely a shelter wherein he eats and sleeps; rarely is he to be found inside of it for any other purpose, unless inclement weather interrupts his usual outdoor vocation.

The Mexican need not mortgage his place in order to make the building of his home possible. Timber is extremely plentiful, palm leaves and lianas are to be had for the gathering, and the only possible expense entailed is that of "labor." The laborer receives from 50 cents to one dollar, Mexican money, for a day's work, or at the most 50 cents in American coin. Should the builder be financially unable to hire assistance, he builds his habitation merely with the aid of his family, and while this may take a little longer to accomplish, it is a matter of small importance, for time is usually not at a premium in Mexico.

The owner locates the house according to the dictates of his fancy, and if possible on some convenient spot best protected from the weather and near water and shade. The first step in the building operations consists in digging four fairly deep post holes at the corners of the rectangular area to be covered by the structure, which is usually some 40 by 30 feet. The posts, formed from the trunks of trees of suitable size, are redwood or sometimes mahogany. Redwood is especially suitable for this purpose, as it excellently resists the attacks of insects. Where possible the builder selects trunks which have lain on the ground for some years, and in which the outer fibers have decayed, leaving only the sound and hard interior portions. The posts are placed in the holes and secured therein with some degree of care, for they are the main supports of the entire structure, which consists principally of the roof. If the house is of larger size, additional supporting posts are sometimes added between the corner ones. The uprights, which are usually so selected that there is a crotch at the upper end, support horizontal connecting timbers at a height of some ten feet from the ground, and these in turn carry the framework of the roof.

Metal in the shape of nails or other fastenings is rarely found in a building of this type. Nature has come to the assistance of the peon by providing him with a strong and plentiful binding material, with which he securely ties together the different members of the framework. This natural twine or rope is found in the parasitical lianas which grow wild in vast quantities, depending from their host growths in lengths up to 50 feet. These *larias*, as they are called, are thin and flexible, of considerable tensile strength, and are gathered and used while still green. When the horizontal beams have been tied to the uprights by means of these vines, the frame of the structure is complete, and the next step, the most important one, is the building of the roof. The rafters are the trunks of small trees cut to the proper lengths and set up on the ground with their peak ends tied together. The roof framework is braced and stiffened by longitudinal and cross pieces, and then the whole, with the accompaniment of prodigious noise and much picturesque profanity, is hoisted upon these supports and securely lashed in place, all the builders, large and small, taking part in this operation.

The framework is now completed, and the construction of the roof thatch is begun. The covering usually consists of dry palm leaves, though frequently the drying is dispensed with and the green leaves, 10 to 15 feet long, are utilized directly. The *mozo* or workman who gathers the leaves brings them to the place of operation on his back in bundles of a dozen or more, and the uninitiated stranger is frequently astounded to see a great mass of green ambulating along on a pair of naked brown feet, no other part of the carrier's anatomy being visible. The leaves are prepared for use by cutting away the growth on one side of the stem. This can be clearly seen in one of the accompanying engravings. The leaves are then placed upon the roof and lashed in position against the rafters, the work beginning at the bottom with each leaf overlapping the one beneath it. Double leaves are used at the peak, covering both sides of the roof at that point. This finishes the roof, whose thatch is some 6 to 12 inches in thickness, and is impervious to the heaviest tropical downpour. Sometimes an ambitious builder will carry the roof beyond the walls and construct a porch. At all events the eaves are carried far enough to insure the dryness of the interior even if the building be without side walls, for the rain, usually unaccompanied by wind, generally falls straight downward.

The walls are formed by tying uprights of saplings or split bamboo to horizontal cross pieces. This may or may not be supplemented by a species of thatching shown in one of the photographs herewith. Crude door and window openings are provided as the builder desires. The windows are literally openings, while the doors are sometimes, though not generally, closed by a few rough boards fastened together with stray nails secured from packing boxes picked up somewhere, but more frequently by one rough plank merely secured with a wooden peg. The floor is of hard trodden earth or clay. In some of the more pretentious dwellings, there is an upper story formed by a floor of loose bamboo sticks under the roof. In this case the stair consists of a single tree trunk deeply notched on opposite sides for the user's feet. The foreigner experiences great difficulty in using this novel staircase, for it requires considerable dexterity, but the natives "run up stairs" with the agility of monkeys.

The furnishings of the house are primitive. The inhabitants sleep upon hard canvas cots, or upon cots made of bamboo and old coffee bags, or merely upon mats laid on the floor. Sometimes the owner is happy in the possession of a hammock discarded by some planter or ranch owner. In one corner is a rude clay or adobe oven or cooking range, upon which the family's meals are prepared. No provision is made for the outlet of the smoke, and this finds an exit through doors, windows, or crevices in the walls. The ubiquitous tortilla table occupies another corner. This is a flat stone placed on four short legs and slightly inclined, on which is ground the corn for the tortillas, a kind of pancake.

BUILDING THE SIDE WALLS BY LASHING SAPLINGS TO HORIZONTAL SUPPORTS.

THATCHING THE ROOF WITH PALM LEAVES WHICH HAVE BEEN TRIMMED ON ONE SIDE OF THE STEM.

A GROUP OF HOUSES WITH WALLS AS WELL AS ROOF OF THATCH.

THE HOMES OF MEXICAN PEONS.

a rough table and a few empty boxes for chairs complete the outfit. In some of the more populous villages are found large buildings which serve as sleeping quarters or dormitories for a considerable number of individuals, sometimes fifty to a hundred men and women living therein in community of interests. Here the cots or bunks are placed in tiers close together, and we can imagine that these domiciles are usually uninviting to the foreign eye and particularly the foreign nose.

Frail as structures of this character apparently are, they usually last for years, certainly during the builder's life, and often for several generations. They make very poor risks, however, for fire insurance companies, as they are as inflammable as so much tinder, and when abandoned are most expeditiously destroyed by burning. There is little difference in construction between houses, barns, sheds, warehouses, offices, etc. Many of the buildings have no side walls, and stables, storehouses, and the like, are often of this form. Frequently, too, the foreigner or wealthier Mexican has an open-air dining-room of this construction.

AN OPEN SHED OF A TYPE OFTEN USED AS WAREHOUSES.

THE TRAINING OF AERONAUTS IN FRANCE.

There is in France, strictly speaking, no school for the training of aeronauts and construction of airships in which a definite and prescribed course of study or lectures is pursued. Such instruction and practice in aerostation as are offered are provided by clubs, and by the government in connection with the military service. There are in Paris four rather important aeronautical societies or ballooning clubs, and five similar organizations elsewhere in France. These clubs were established for the promotion and practice of ballooning as a sport, as well as for scientific study and experiment, and in general for the encouragement of all that pertains to aerostation. In some of these young men are given practical training, taught the theory of construction, and use of balloons, and instructed practically concerning balloon materials and parts, such as the net, anchor, basket, the guide rope, valves, the tying of ropes, knots, etc., the preparation of a balloon for an ascent, and the care and return of the material after descending. Under certain circumstances these pupils — who are always members of the club—may take part in the ascents, learn how to handle the balloon in the air, and descend under different conditions of daylight and weather. If they acquire a certain efficiency in all this, and pass a prescribed examination, they are permitted, when drawn from military service, to enter the "Bataillon d'Aerostiers," or balloon corps of the army. This battalion is established, according to the American Consul-General in Paris, in what is known as the "Menagerie," the old Zoological Garden, formerly belonging to the palace and park at Versailles, and situated between that city and the military school at St. Cyr. Formerly these bataillons d'Aerostiers were distributed throughout the provinces, but since 1870 the government has concentrated them at the "Menagerie," and they form part of the regiment of engineers garrisoned at Versailles. The post is under the control of a commandant, and the men are taught and practise the handling and care of balloons, of which there are in use several of moderate size, none with a capacity exceeding 900 cubic meters. Besides the balloons, the apparatus and material necessary for inflating them, the equipment includes a plant for making hydrogen gas, which was formerly exclusively used for inflation; but more recently illuminating gas has been used on account of its more moderate cost. Most of the ascents made there are with captive balloons. The men who enter this branch of the service are trained at the annual maneuvers for active duty in case of war. Their teaching is practical, and includes all that pertains to preparing, loading, unloading, inflating, deflating, packing up, transporting, etc., but they make no ascents. This is the exclusive duty of officers. Their service lasts ordinarily two years, when they are discharged, subject for call to duty in the military balloon corps in case of war. The main incentive to service is that it offers a less arduous form of duty than ordinary service in the ranks, and, moreover, keeps the young recruit within convenient distance of Paris; but many of the young men have no special gift for the management of a balloon, and opinion among experts is somewhat divided as to whether most of them learn much that would really be useful in the event of actual war.

The second, and far more important institution of this kind in France, is known as the "Etablissement Central du Matériel de l'Aerostation Militaire" at Chalais, Meudon, about midway between Paris and Versailles. It has been in existence nearly a hundred years and is divided into two general departments, as follows: 1. The arsenal, at present under the command of Commandant Bouttiaux, at which are manufactured balloons and every form of balloon material and equipment for use of the aeronautic service of the French army. 2. The Department of Tests and Experiments, under command of Lieut.-Colonel Bertrand, where new inventions are developed and tests made with gas and every form of material and appliance which pertains to military aeronautics. The institution is in fact a combined arsenal and experimental station, but it is in no proper sense a school, since it has no definite course of instruction, no textbooks or specified course of lectures. It is there that the official experiments in aerostation, tests of new materials and original features in construction are made by military experts. It was there that Colonel Renard, twenty-three years ago, built and experimented with "La France," the first dirigible balloon. These two institutions, the "Menagerie" training camp near St. Cyr, and the arsenal at Chalons, are the two principal government stations for balloon materials in the neighborhood of Paris. There are besides several minor depots of such material at military posts near the frontiers, where it would be promptly available in case of war. Moreover, two of the French army corps are provided with large dirigible balloons of the Lebaudy type, built for the purpose by the Lebaudy brothers, who trained at their works the first soldiers who were instructed in inflating and navigating them.—Journal of the Society of Arts.

A TYPICAL MEXICAN PEON VILLAGE BUILT ABOUT AN OPEN SPACE IN THE FOREST.

THE HOMES OF MEXICAN PEONS.

Experiments by the Forest Service at its timber testing station at Yale University, show that green wood does not shrink at all in drying until the amount of moisture in it has been reduced to about one-third of the dry weight of the wood. From this point on to the absolutely dry condition, the shrinkage in the area of cross-section of the wood is directly proportional to the amount of moisture removed. The shrinkage of wood in a direction parallel to the grain is very small; so small in comparison with the shrinkage at right angles to the grain, that in computing the total shrinkage in volume, the longitudinal shrinkage may be neglected entirely. The volumetric shrinkage varies with different woods, being about 26 per cent of the dry volume for the species of eucalyptus known as blue gum, and only about 7 per cent for red cedar. For hickory, the shrinkage is about 20 per cent of the dry volume, and for long-leaf pine about 15 per cent. In the usual air-dry condition, from 12 to 15 per cent of moisture still remains in the wood, so that the shrinkage from the green condition to the air-dry condition is only a trifle over half of that from the green to the absolutely dry state.

MODERN PHYSIOLOGY.*

HOW THE PRESENT EXPERIMENTAL STAGE WAS REACHED

BY PROF. FREDERIC SCHILLER LEE.

Physiology has long since passed the stage where unaided observation alone is of value, and has become pre-eminently an experimental science. It is the task of the experimenter to alter one or more of the conditions under which the phenomenon occurs, to observe its change, if such appears, and thus to throw light upon the nature of the phenomenon itself, its relation to both its original and its changed conditions, and its causes. Herein lies the enormous difficulty of physiological work. The vital process is of a complexity unapproached, much less equaled, in the inorganic world. Living substance is never exactly the same at two successive periods. It is ever in unstable equilibrium, the seat of constant change, of augmentations and depressions, of physical and chemical mutations, and of what we in our ignorance call spontaneous activities; and the conditions of its activities are manifold and often obscure and unsuspected. To maintain the majority of these conditions intact, while altering one or more, is a superhuman task, one that is approached, but probably never realized in its entirety. The physiologist is thus constantly baffled in his pursuit of the desired object, and must needs exercise unwonted patience in the face of not infrequent failure. His progress is slow and his results can only approximate the mathematical exactness of the experimenter who deals with stable non-living matter.

Since the time when physiology assumed its physico-chemical aspect and entered upon its modern phase, what has been the trend of its research? Its energies were first directed chiefly to the study of the mechanical and other physical problems of the organs of vertebrate animals. The electrical method of stimulating living substance was devised, by which the latter can be made to act at the will of the experimenter—a method the importance of which can scarcely be overestimated. The graphic method was early introduced and has been developed to the greatest refinement. By its use organic movements can be recorded graphically, and can then be easily analyzed into their space and time components and be studied at leisure. The working of the organs of the mammalian body, considered as physical machines, is now fairly well understood, although specific problems within this field are still being actively investigated. Very exact computations have been made of the amount of energy given off by the body in the form of heat and of muscular work, and it has been found to correspond very closely with the income of energy derived from the food and whatever bodily material may be consumed during the experiment. The principle of the conservation of energy applies as well to the living as to the non-living machine.

Chemical physiology, or, as it is now often called, bio-chemistry, developed gradually during the last century but did not become prominent until the last decade. It occupies now a foremost place among the branches of biological science. Much biochemical work is morphological—the determination of the chemical constituents and structure of substance once living, from which inferences may be drawn as to the chemical nature of living substance. Unfortunately living substance cannot be chemically analyzed directly, since all known methods at once kill it, and there is left only the non-living proteins, carbohydrates, fats, and other organic and inorganic compounds, the individual bricks, or, better, cleavage products of the complex unity. In determining these and their relationships great progress has been made, but we of the present are far removed from that state of smug satisfaction of some of the earlier investigators, to whom a living body represented only so many molecules of carbon, oxygen, nitrogen, hydrogen, sulphur, and phosphorus. The problems of the chemical physiologist, as distinguished from the chemical morphologist, are in general the problems of metabolism—which the Germans have aptly styled "Stoffwechsel"—the chemical changes undergone by matter in the process of living, its building up and its breaking down, its anabolism and its katabolism. The intricacies of metabolism can scarcely be conceived by one not familiar with the attempts to follow them, and the biochemists deserve much credit for the ingenuity of their methods. They have been more successful in determining and isolating the multitudinous katabolic products of vital activity, both the intermediate and the final products, and in discovering clues to the individual steps in the katabolic process. They have even succeeded in making synthetically many of these vital products, an achievement which was inaugurated by Wöhler in 1828 in the manufacture of urea. The laboratory synthesis of vital products has become, indeed, almost a daily occurrence and has hence lost its former miraculous appearance. It is not, however, certain that the laboratory methods and the physiological methods employed in such synthesis are identical. The steps of the anabolic process are still obscure, and until they are better known, we can hardly look forward with confident satisfaction to the artificial manufacture of living substance. Yet physiological alchemists do exist, and the successful making of "life" has been heralded more than once to a sensation-loving world. Such an achievement is for the present only an idle dream, serving to gently and pleasurably titillate the cerebral cells of the dreamers.

Of recent years physiological physics and physiological chemistry have come to meet on common ground within the realm of the new science of physical chemistry. It has come to be clearly recognized that living substance consists of organic colloidal, or jelly-like, material, permeated by inorganic matter. The colloidal matter seems to consist of enormous complex molecules and aggregates of molecules; the inorganic matter partly of smaller, simpler molecules, and partly of ions, which are atoms or groups of atoms charged electrically. As the life process goes on, the living substance being now in a state of activity, now in a state of rest, there is a constant chemical and physical interplay between the two material constituents, and a constant interchange between them and the surrounding medium, in which the laws of osmosis play a prominent part. The careful investigation of the nature of these internal and external exchanges seems to be illuminating many time-honored physiological enigmas, such as absorption, secretion, excretion, and other instances of the passage of substances through membranes, the electrical phenomena of tissues, the nature of the nerve impulse, the fertilization of the ovum and the general nature of chemical changes within protoplasm—enigmas which have been constantly quoted in support of the vitalistic conception. But we should not be tempted by success along these lines to claim, as is sometimes done, that the life process is merely ionic or electrical or osmotic in nature. In investigating physiological problems by the aid of modern physical chemistry, we seem to be brought at times perilously near the electron theory of matter, and we are tempted to hazard the guess that the establishment of that theory would place the physiologist under renewed obligations to the physicist.

The study of ferments, too, is assisting—strange, innumerable, intangible bodies of uncertain nature, which, present in minute, almost imperceptible quantities, seem to facilitate vital chemical actions without entering directly into them. In the early years ferments were recognized as mediating the processes of digestion, and but few of them were known. Of late their number has been enormously increased, and a corresponding number of intracellular or extracellular chemical processes has been ascribed to their action. Each has its own specific chemical reaction to facilitate, and in many cases, at least, their action is reversible, i. e., one and the same ferment can aid both the decomposition of a complex substance into its constituents and the synthesis of those constituents into the complex substance. The ferments that function in vital processes are products of living matter, but recent research makes it increasingly clear that they act merely like catalytic agents of inorganic origin. The study of ferments has its dangerous aspect, for more than one investigator, with an eye single to their universality and efficacy, has in his cyclopean enthusiasm come to suspect that all the chemical processes of living organisms are mediated by them, and has even been led to make the narrow and unwarranted assertion that life itself is merely ferment action.

The discovery of protoplasm and the establishment of the cell theory have exercised a profound influence on the science of function. Until nearly the middle of the last century physiologists were in a sense groping in the dark, for the reason that although they were endeavoring to unravel the mystery of living substance, they had no conception of the real nature of that substance. When the times were ripe they were quick to recognize the value and significance of the new discoveries, and, indeed, played valuable parts in formulating and establishing the new doctrines. With the clear recognition of a definite substance as the physical basis of life, their energies were more definitely directed than before. One result of this has been the increasing and powerful growth, during the latter part of the last century and the early years of this, of general physiology. The rise of general physiology represents a movement away from the earlier study of the mechanics of organs, toward that of the vital phenomena of living substance itself, irrespective of its special position within the organism. General physiology is pre-eminently the physiology of to-day, whether its point of view and methods be physical or chemical.

The principle of organic evolution is in its essence a physiological principle. It represents a great physiological experiment which nature has been making since the beginning of living things, and is continuing to make. But the discovery of the facts and principles of organic evolution and the establishment of its theory have been accomplished only in small part by professed physiologists. Not even has the evolution of function—a field of great possibilities—been explored except in a few small and isolated spots. The necessity of properly controlled experimentation in settling the vexed problems of evolution is, however, at last being recognized, and the next few decades promise to witness great advances in the discovery of the ways in which nature has made her great experiment.

It is not strange that with its intricacies and peculiar difficulties the solving of the problems of nervous function has proceeded slowly. The facts that nervous function is a property of the nerves, and that the brain is the seat of the mind, were probably first capable of scientific proof by the Alexandrians in the fourth century before Christ. The two great functions of sensation and motion were also recognized by the ancients, but that they were mediated by different nerves was first demonstrated by Sir Charles Bell, so late as 1811. The idea of the specific energy of nerves—a phrase which means specific activity—or the general principle that each nerve has specific functions with which it always responds, no matter how stimulated, was definitely proposed by Johannes Müller in 1826 for the nerves of special sense, and later was generalized for other nerves and other tissues. Since then great progress has been made in discovering by experiment the specific functions of individual nerves and in formulating therefrom theories of the general functions of nervous tissues. That different nervous activities are associated with different portions of the brain was early surmised, and before the middle of the past century such important nervous centers as those controlling respiration and the beat of the heart became located. Since then the nervous mechanism of a host of unconscious organic processes has been discovered. That the psychic portion of the brain does not function as a unit, but consists rather of a complex group of nervous organs, each with its specific functions—a fact that is of great moment in elucidating the relations of brain and mind—has been known for only a little more than thirty-five years. For it was in 1871 that Fritsch and Hitzig, by stimulating specific small areas of the surface of the cerebrum and obtaining in response specific muscular movements, first demonstrated a specific cerebral localization of functions. Since then the task of mapping out the outer layer, or cortex, of the cerebrum of a few mammals and man into centers, joined by nerve fibers with specific organs of the body and employed for the control of separate groups of muscles and for the work of the special senses, has proceeded to a considerable degree. Thus, we are now able to point to a certain portion of one of the convolutions of the cerebrum and say that its nerve-cells, or neurones, mediate the volitional act of contracting one's biceps muscle; we can say that the neurones in other localities mediate the separate acts involved in locomotion; in others, the changes of facial expression; and in still others, the enunciation of thoughts in the form of spoken words. We know with considerable exactness the positions of the separate centers for sight and hearing; less exactly those of the other special senses. Besides the sensory and motor centers, evidence points strongly toward the existence also of cortical regions which are elaborately joined to one another and to the sensory and motor regions by means of innumerable nerve fibers, and the function of which is to correlate, harmonize, or associate the work of the sensory and motor centers. Such association centers thus help to mediate the more complex psychical phenomena, such as memory and the association of ideas. We can even formulate helpful hypotheses of the neural

* Abstracted from a lecture on Physiology delivered at Columbia University in the series on Science, Philosophy and Art.

accompaniments of various psychoses. According to James's theory of the emotions, for example, the perception of the automobile about to run us down leads to the feeling of fear only through the mediation of various organic processes, such as a quickening of the heart beat, pallor, and trembling. The accompanying series of neural processes would consist in the activity, in turn, of visual sense organs, neurones conveying the visual impressions to the brain, cerebral neurones mediating the sensation and perception of the terrifying car, motor neurones controlling the peripheral muscular actions that are involved in the organic processes, neurones conveying to the brain the impressions of altered heart beat, constricted arteries, and trembling muscles, and lastly cerebral neurones mediating the feeling of fear. Because of its difficulty, much of the work of geographical exploration within the central nervous system is at present necessarily inexact, and moreover there is still much *terra incognita*. And even though we have thus come to know the gross functions of specific parts of the higher mammalian and human brains, we still know all too little of the processes by which the different parts are coordinated and made to subserve the many complex needs of the organism. The recent work of Prof. Sherrington on the integrative action of the nervous system, is an admirable example of the kind of investigation that is needed in this field, and by its very excellence helps to emphasize the lack of our knowledge. The laboratories of physiological psychology, now numerous, are making many valuable contributions, especially to our knowledge of the mechanism of the special senses. But when I make a summary of what we now know of the physiology of the nervous system, I come to realize anew its paucity, compared with what we ought to know and will know, I am confident, in the long future. Here, it seems to me, is a field sadly needing tillage, and one where, though tillage be extremely difficult, the yield is certain to be rich.

All investigation here will lead up, in a sense, to the solving of that problem of problems, which has been for ages the focus of discussion and speculation, the problem of consciousness—"at once the oldest problem of philosophy and one of the youngest problems of science." For centuries it has been thought about, talked about, written about, and with what result? The elaboration of hypothesis after hypothesis, which smell of the lamp—fabrications of the philosopher's cell rather than of the physiologist's laboratory. Almost without exception they are elaborate exercises in dialectics, rather than real portrayals of the nature of that most striking of physiological phenomena. To the physiologist they are almost without exception arid and unsatisfying. "Words, words, words," replies Hamlet to the question of Polonius. At first thought, the theories of dualism and interaction seem best adapted to the obvious facts of human experience; the brain and mind are two distinct entities usually intimately associated, and each capable of inducing phenomena in the other. But deeper brooding, and especially a recognition of the mode of action of the non-psychic portions of the nervous system and the close dependence of psychic on cerebral phenomena, of "how at the mercy of bodily happenings our spirit is," make us seek a more genuinely physiological explanation.

The physiologist recognizes as the morphological basis of nervous actions the neurone or nerve cell, consisting of a compact cell body, from which radiate outward filaments, the nerve fibers. He finds in the nervous system of the higher animal or man millions of such neurones and many more millions of nerve fibers. These constitute seemingly a confused and inextricable mass, but by careful study he has been able to discover an exact and indefinite, though excessively intricate, nervous architecture. He finds that the bodies of neurones act as central stations, to which and from which flow the nervous impulses along the nerve fibers: the incoming impulses constituting the centripetal, or afferent, or sometimes sensory, impulses; the outgoing constituting the centrifugal, or efferent, or sometimes motor impulses. He recognizes as the physiological basis of nervous action, the reflex action, consisting of an afferent impulse, a central process, and an efferent impulse. He sees reflex acts combined in innumerable ways, and augmented and depressed by other reflex acts. He sees many of the most complicated actions of the individual performed with the aid of this reflex mechanism and without the aid of consciousness. He recognizes that a large proportion, if not the majority, of the individual's actions are reflex and unconscious actions. Lastly, he finds in reflex mechanisms no mysterious principle, but an ensemble of the same physico-chemical phenomena, which in one form or another he finds in other than nervous tissues, and in which the principle of the conservation of energy holds good. Turning now to conscious actions, he sees how indispensable to them, at least in the higher animal species and man, is a certain part of the cerebrum, especially the outer layer or cortex; and how the degree of intellectual development varies with the extent and complexity of this material structure. He sees how injury or disease of this part, or anything interfering with its proper activity, changes the individual from a sentient being into a non-thinking reflex machine. He sees acts, once consciously performed, now relegated to the unconscious reflex sphere. He sees how consciousness disappears in sleep, and how its manifestations vary under the influence of drugs. The cerebral cortex is composed of numberless neurones and is connected by afferent and efferent paths with the other portions of the nervous system. With these facts in mind, and though recognizing the intricacies of mental phenomena, the physiologist gets into the way of thinking that after all the mechanism of cortical actions is really the same as that of other nervous phenomena. He sees no objective, *a priori* reason why an entirely new causative principle should be introduced to explain the action of this small fraction of the nervous system. Whatever its nature, consciousness appears to him, not as a distinct entity grafted on to certain nerve structures, but as merely one of the modes of manifestation of the activity of those structures, just as chemical, thermal, and electrical phenomena are other modes. Being thus one of the signs of nervous activity, the physiologist finds it difficult to see how consciousness can act as a cause of nervous activity, any more than can the heat given off in such activity react to produce itself. The physiologist sees that nervous systems, with all their functions, have undergone an evolution; he recognizes orders of consciousness—a low, simple, gradual beginning, he knows not where, a progressive increase in complexity as nervous systems complicate, and the final culmination in self-conscious man. The relations of consciousness in its simplest form to the nervous system seem to be the same in kind as in the human being. For the physiologist, looking at the matter in this light, Huxley has probably formulated the best working hypothesis in his famous essay, "On the hypothesis that animals are automata." After a lucid analysis of the actions of animals lower than man, he says: "The consciousness of brutes would appear to be related to the mechanism of their body simply as a collateral product of its working, and to be as completely without any power of modifying that working as the steam whistle which accompanies the work of a locomotive engine is without influence upon its machinery. Their volition, if they have any, is an emotion indicative of physical changes, not a cause of such changes." And later: "It is quite true that, to the best of my judgment, the argumentation which applies to brutes holds equally good of men; and therefore that all states of consciousness in us, as in them, are immediately caused by molecular changes of the brain substance. It seems to me that in men, as in brutes, there is no proof that any state of consciousness is the cause of change in the motion of the matter of the organism. If these positions are well based, it follows that our mental conditions are simply the symbols in consciousness of the changes which take place automatically in the organism; and that, to take an extreme illustration, the feeling we call volition is not the cause of a voluntary act, but the symbol of that state of the brain which is the immediate cause of that act. We are conscious automata." Objection after objection has been raised to the automaton hypothesis. It has been dialectically disproved many times. Its upholders have been charged with all the sins against logic, common sense, lucubration, spirituality, and orthodoxy. And yet it will not down, for of all hypotheses it seems to accord most closely with the facts of neural physiology, as we know them to-day. It may perhaps prove to be not a finality; but whether in the distant future it be found correct or incorrect, it is from its general standpoint, it seems to me, that the physiologist of the present epoch can do his most helpful experimental work. The problem of consciousness should be taken into the physiological laboratory, and the conditions of the manifestation of psychic phenomena should be investigated by laboratory methods. All mental processes, even to the last degree, are dependent on and have their basis in brain processes. The physiologist should study in minute detail the cerebral process of each mental act. He can thus inform the psychologist as to the conditions under which psychic phenomena occur. "An individual fact is said to be explained," says John Stuart Mill, "by pointing out its cause." And again, "The cause of a phenomenon is the assemblage of its conditions." In this sense the explanation of consciousness, it would appear, ought to come, sooner or later, from the physiologists.

I have spoken of the physiological aspect of other sciences. Pathology, the science of disease, or, in other words, perturbed function, is peculiarly close to physiology, for there is no sharp line of demarkation between the normal and the abnormal. We may assume the successive chemical substances involved in a certain progressive physiological act to be represented by the series A, B, C, D, in which A is the substance from which the chain proceeds. By analytic and synthetic processes A gives rise to B, B to C, and C to D, which is the final end-product of the metabolism. Even with the same quantity of A and the same strength of stimulus, the quantities of B, C, and D produced in successive repetitions of the act may vary considerably, owing to unknown factors. It is only when the intermediate or final products become markedly increased or diminished in quantity in comparison with their usual amounts, that we speak of the function as pathological. The excitability of cells may be greatly augmented or diminished and still be within the limits of the normal. A tissue may grow excessively, as in tumors, or may waste away, and yet normal function be not seriously interfered with until remote limits are passed. Bacteria may live physiologically within an animal body. They produce and cast off toxins, which intrinsically are poisonous to the cells of their host. These, however, cause a physiological production of antitoxins in the body cells. So long as the antitoxins are sufficient in quantity and strength, they neutralize the poisonous toxins. If the latter get the upper hand they augment or depress the physiological activities of the cells of the host, and we speak of the result as a perturbation of function. The power of the organism to adapt itself to changed conditions and to maintain its physiological status is little short of marvelous. When, in spite of all endeavors, the physiological status is overwhelmed, then is the time for the pathologist to investigate and the physician or the surgeon to attempt to cure.

As in the biological sciences, so in the medical art, there exists a distinction between the morphologist and the physiologist, between the surgeon and the physician. The surgeon is the medical morphologist. His task is to remove diseased or injured tissue, to reunite separated structures, to restore structure or stimulate to its restoration, in short, to make structure normal, so that normal function may follow. The physician, on the other hand, is the medical physiologist. It is his endeavor to restore normal function. His life-long labor is an exercise in physiology. He should know his physiology as the surgeon should know his anatomy, minutely and to the last degree. He should know what health is before he tries to restore it. We all realize how rarely this ideal is reached, and we all have experienced the dire results of medical empiricism. Huxley likens nature and disease to two men fighting, the doctor to a blind man with a club who jumps into the mêlée, and strikes out right and left, sometimes hitting disease and sometimes hitting nature. Would not his blows be more telling if he were quite sure which of the combatants was nature and which disease? Wherein he fails to avail himself of present knowledge he is culpable. And yet he is not to be charged with the whole burden of his failure to cure. Some of this should be shared, I regret to confess, by the physiologists, for they still know too little of the normal action of the vital mechanism. So far is this true, that I am convinced that one of the surest and quickest means of inaugurating a rational and effective art of medicine is through the advancement of physiological discovery. All physicians must be in part empirics until the physiological millennium is ushered in.

RUBBER PLANTING IN SAMOA.

THE large results which have been attained with hevea culture in Ceylon, the Malay Straits, and the Straits Settlements, have induced the planters of Samoa to turn their attention to rubber planting, and it is expected that within a few months 300,000 hevea trees will be planted out in the island. The importation of 100,000 hevea plants into Samoa from Ceylon as so-called "stumps" has been a complete success. The difficulty in obtaining hevea plants has been solved. How it will stand as regards disease, especially the Limumea, and what yield the rubber will give in Samoa, cannot be forecasted. According to the report of Mr. Acting Vice-Consul Trood on the trade of Samoa, just issued (No. 4017, Annual Series), there are three rubber plantations now in existence in Samoa. The first has several thousand acres, the second 800 acres, of which half are cultivated; and the third, 350 acres in rubber and cacao, and 100 acres in rubber solely. All promise excellent results when the trees are ready for tapping. The great advantage which Samoa enjoys over the adjacent islands is that it is subject to hurricanes only at extremely long intervals. There has been no severe storm since 1889, and even if a hurricane should take place within the next few years, it is pretty certain to be followed by a period, varying from 25 to 30 years or more, during which there will be no gale worth mentioning. The rubber tree has no very great power of resistance against storms, and Dr. Preuss, who has been making a study of the question of rubber-growing in Samoa, suggests that the plantations should be provided with wind breaks, for which purpose the *Ficus elastica* is best suited. This tree grows quickly, spreads out widely, and forms a full thick crown. It has great resisting powers against wind, and, besides, gives a yield of first-class caoutchouc.

Artificial Kumys.—100 parts of condensed milk is mixed with 1,000 parts of water; to this are added 1 part of lactic acid, 0.5 part of citric acid, and 15 parts of the best Jamaica rum or arrack. Saturate with carbonic acid and bottle.

CAPTURING THE CROCODILE.*

THE ACCOUNT OF A HUNTER.

BY JULIAN A. DIMOCK.

MANY Americans use the names crocodile and alligator indiscriminately, for they do not know that representatives of both these genera are found in their country. Indeed, until within a comparatively few years the presence of the crocodile was not suspected even by scientists. In 1875 a couple of specimens were obtained, and thereafter a scattered few found their way to the museums; but it was not until 1889 that any number were obtained, or that there was any general knowledge of their existence. In that year Dr. Viele of the Chicago Museum obtained about a dozen skins and skeletons for his own and other museums, and my father and I secured half as many for college and other collections. It was an old guide of ours who brought the news of the discovery of "alligators that were not alligators," of which rumors had been locally current. With him at the helm we made sail for the Madeira Hammock. This, the habitat of the Florida crocodile, is a narrow strip of land at the extreme southeast end of the peninsula lying between the southern boundary of the Everglades and the Bay of Florida. But for the exploring fever that runs in the veins of mankind, these creatures would have remained undiscovered; for the Everglades sheltered their home on the north, while the bay, on the south, offered scarcely more inducement to the wayfarer. Numerous mud-flats stretch tentacle-like arms across the path, and the intersecting channels are narrow, tortuous and hard to find. The mud is sticky and bottomless. We made our way through this maze, for which the guide merited the commendation from the wreckers of the Keys which he afterward received. We stirred the mud of the bottom for many miles, and barely missed staying ashore on the flats.

"There's a crocodile now!" sung out the guide. Two hundred yards away we saw the two knob-like points of the creature's eyes and nose as they appeared upon the surface of the water. Contrary to his cousin the alligator, the crocodile seems to prefer salt water, and this one was more than a mile from shore. The schooner was thrown up in the wind, the wheel given over to the cook, the skiff tumbled overboard, oars, harpoons and lines thrown in, while the guides and my father jumped for the little boat. In thirty seconds, under the impulse of oars and poles, she was dancing through the water, and big waves were rolling from the bows. But the quarry had taken fright, and when they reached the spot where he had disappeared only some muddied water remained as evidence that our eyes had not deceived us. That night we anchored by Deer Key, and on the morrow the real hunt began. In hunting alligators the rifle is the weapon used, for the reptile is curious to a degree that leads to his destruction, and is not overburdened with shyness. Having once seen his head, you can wait with confidence that it will appear again at no distant time, while at night no alligator can resist the fascination of the jack-lantern. With the crocodile this is all changed—he is not sufficiently curious to show himself as long as he has reason to think that an enemy is at hand, and from the light of a bull's-eye he runs with fright. Many hunters think that the eye of the crocodile does not reflect the rays of light as does that of the alligator, but this is an error. The eye does reflect the gleam, but the creature is too shy to be held by its attraction.

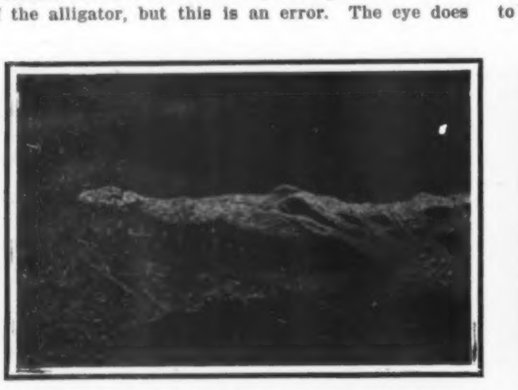
Harpooning is the most practicable way to capture the crocodile. Pursuing this method you stand, harpoon in hand, in the bow of the skiff and are poled across shallow bays and through twisted rivers. Sometimes you see the head of a crocodile on the surface of the bay, sometimes you cross his trail of roiled water and follow it to its end. Occasionally you become aware of his proximity by the odor of musk, and diligently seek to pierce the curtain of muddy water that hides him. You may hear him crash into the water from his "slide," or sun-bath, on your approach, or you may find him at home in his cave. These, dug

A DENTAL DISPLAY.

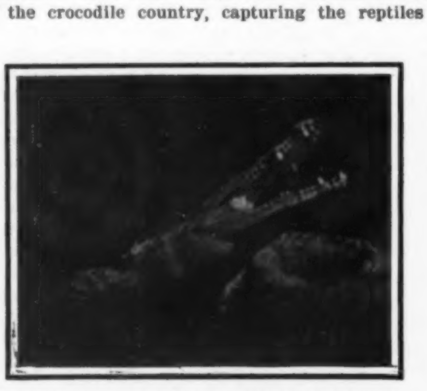
by the creatures themselves, have entrances below the water, but are believed to always rise above its level at the far end, so that the occupants may breathe without leaving shelter. The length of the caves varies from a few feet to more than a score. When your quarry is found, you will see but a quickly-moving shadow below you, and this you must hit with your iron, avoiding the armor-plated back and the impenetrable skull. Your nerves must be steady, your eyesight keen and trained to see beneath the water, and your aim accurate. If the first shot is not successful, the chance of a second is hardly worth considering. It may happen that you will find the reptile in a narrow creek, and with two skiffs one can be kept at either end, and thus make it difficult for him to escape. Our largest specimen was just over fourteen feet long, and was found in such a creek; which was fortunate for us, as before securing him we hit him seventeen times with harpoons. His disposition was considerably ruffled by this treatment, and at last he came to the surface with a rush, prepared to take a hand in the game of pursuit himself. He began on my skiff. With wide-open jaws he attempted to swallow the whole thing. A broken tooth saved the boat, and possibly the occupants. Finding him so difficult to handle, we abandoned our idea of saving him for an aquarium, deciding that he would better befit a museum. Since 1889 I have made several excursions to the crocodile country, capturing the reptiles for aquariums and for purposes of photography, but have never killed one, save by accident. It is the tourist-sportsman who has doomed this race. If he could be induced to throw away his rifle and use the camera in its place he would contribute to the knowledge of natural history, to the entertainment of his friends, and preserve for the interest of posterity a harmless and curious creature.

The pursuit, for this purpose, should be modified, for it is of importance that the creature be not injured. The harpoon must be a tiny one and stopped with rope to prevent its penetrating further than just beyond the barb, and it must be carefully placed to avoid the chance of reaching a vital organ. A net may be substituted, or, if the crocodile can be found in his cave, he may be sometimes caught with a noose. Tie his jaws together and he becomes as harmless as a kitten, and may be taken aboard the skiff and carried to any convenient prairie land. Here untie him and follow him around with your camera. It will be quite as exciting as killing him. Sometimes he will jump at you at less than his length away. If you can catch his open jaws on your sensitive plate before you too jump, you will have a memento worth more than twenty stuffed skins and as convincing as the sworn statements of a score of hunters. When he is quiet approach him within a yard and obtain pictures of his head and teeth. When you have exhausted your ingenuity in devising different poses and have used up your plates, turn him loose and let him go, remembering that "there are others."

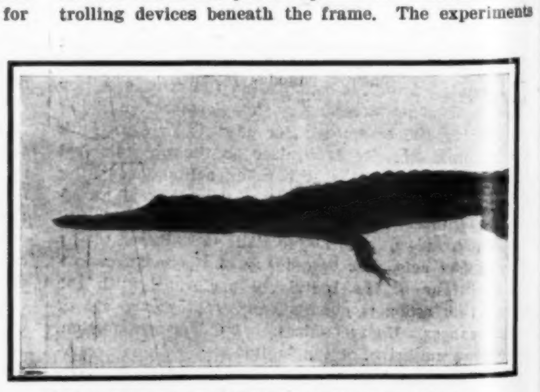
Although belonging to the same family, the alligator and the crocodile seem to be unneighborly. For, until the practical extinction of the latter, no alligators were found in the Madeira country. Within the last two years, a number of small ones have been seen there, which suggests that it is race antipathy rather than different requirements which has kept these cousins apart. The prominent difference between the two is in the shape of the head. Despite popular belief, the jaw action is the same, and the crocodile is less savage than his relative, though more active and far more shy. Once captured he becomes docile, and so remains as long as his jaws are kept tied, and may be safely handled. The alligator, on the contrary, is safe only after decomposition has set in, for he has a habit of returning to life after he has been "killed," which, with the energetic use of his tail, is disconcerting to the man within his reach. Apart from prejudice, the flesh of both reptiles is eatable, that of the crocodile being more delicate. The eggs are not impossible as food and resemble those of the turtle in taste. The skin of the crocodile will not be accepted by the buyers of hides, as they say that it will not tan satisfactorily. Thus, save as a curiosity, the creature has no commercial value; but so persistently has he been pursued that it is doubtful whether there are to-day enough out of captivity to perpetuate the genus.



NINE-FOOT CROCODILE BEFORE CAPTURE.



SPRINGING AT HIS PHOTOGRAPHER.



SWIMMING—THE FEET ARE NOT USED.

According to the Railroad Gazette, an electrician has for several months been working, under the direction of the Superintendent of Motive Power and Machinery of the Union Pacific Railroad, on a system of wireless or remote control of a truck running on the industrial tracks of the Union Pacific shops at Omaha, Neb. The truck, which carries a storage battery, is capable of hauling a load of 10 tons at a speed of six miles an hour. It carries 144 feet of copper wire made into a ring, and an antenna about 2 feet high, by which the electric waves are picked up and transmitted to controlling devices beneath the frame. The experiments have progressed so far that it is now possible, by the use of the device, to move forward, reverse, stop, or to move at any desired speed by means of the specially shaped antenna and traveling ground communication. Similar antennæ built like a cylinder and tuned to the car apparatus swing from a flag pole 65 feet above the central controlling station. From these are sent waves that control the movement of the truck.

* Country Life (London).

ANCIENT BUDDHIST POTTERY.

AN IMPORTANT DISCOVERY IN BURMA.

BY THE ENGLISH CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

Throughout the whole of Burma there are sites of ancient civilization awaiting excavation; and in view of the importance of the relics there unearthed, and their bearing upon our knowledge of the early inhabitants of the East, the investigations are being carried out methodically and with unremitting care and skill by the British government. There is a special official department for this field of operations, and at the present time several surveys are at work in those areas from which the most important finds are anticipated. Next to Egypt, India, including Burma, is of exceptional interest in tracing the earliest civilization and its extension through the East; and dealing as it does with a race totally different from that which radiated from Egypt throughout Africa, western Asia, and southern Europe—a race distinctly dissimilar in type, characteristics, religion, and mythology—the scientific unraveling of the secrets of these long-since forgotten townships, villages, and sepulchers is of far-reaching importance to the world at large. Moreover, they tend to shed further light concerning the mysteries of the remarkable Eastern god Buddha and the numerous mystical sacred rites and ceremonies incidental to the worship of this deity.

One of the most important branches of the Archæological Survey is that at Mandalay in the Burmese province. This district is particularly rich in Buddha monuments, and the government is preserving all the most noteworthy buildings and relics, some of which are of inestimable value, affording excellent examples of native architecture and decoration during successive eras. The district which has so far proved the most remunerative field of research from an antiquarian point of view is Pagan. In this district there are in all about five thousand pagodas in various stages of decay, some of the most ancient of which have yielded valuable relics. The most noteworthy of these shrines is that known locally as the "Petleikpaya," meaning "the Pagoda of the Curling Leaf," the conservation of which the Indian government is now carrying out. When the authorities determined to investigate the heap of debris beneath which the pagoda is half buried, the fact that the rubbish might yield such important results as have been achieved, was not anticipated. The sum of the researches points to the fact that it evidently dates from the period of Anawrata—approximately 1066 A. D.; but later search has revealed the significant fact that the present building in reality stands upon another similar and older structure, thereby confirming the supposition formerly entertained, that these Buddhist buildings existed in Burma prior to the reign of Anawrata, and that that monarch did not introduce Buddhism into the country, as is generally maintained, but rather developed the religion.

While engaged in removing the debris surrounding the pagoda, the excavators came across the remains of a vaulted corridor, the most prominent feature of which was the decoration of the walls both inside and out with double rows of square reliefs executed in terra cotta, and each of which depicted a particular scene in the life of Buddha during his many transmigrations. According to the tenets of the Buddhist doctrine, every adherent before attaining that enlightenment possessed by the deity must pass through an almost illimitable sequence of existences, and through which even Gautama, who was to become the Buddha, himself had to pass before reaching final emancipation. The outcome of this mythology was that in the very earliest days of the religion, the devotees set to work collecting stories of their leader's doings in successive existences, some of which he passed in the shape of various birds and animals. With each existence is associated some particular story, derived from the extensive folk lore of the country, but attributed to Buddha himself. These stories must have been impressed into the service of the religion at a very early date, but it was the southern Buddhists especially who developed them, and in their scriptures we find more than five hundred such stories, the whole collection being known as the "Jataka" or "Birth Book."

Several illustrations of these stories have been brought to light at other pagodas, but they were of inferior workmanship. In the plaques unearthed at Petleikpaya, however, the workmanship is excellent; and they are in a remarkable stage of preservation. The figures are finely modeled, being sharply cut and as clear as when they were drawn from the kiln, the hieroglyphics are clearly and deeply cut, so as to be easily decipherable. In the accompanying illustrations two of these plaques are shown. An interesting point concerning these terra-cotta illustrations is that to each is attached a number alongside the legend, so that the particular story depicted may be easily found in the Birth Book.

In the first—Sambhava-jât, 518—Sucîrata, counselor of the King of Kuru, is asked by his master to explain the nature of the Service of Truth. Sucîrata confesses his inability to solve the question, and procures its solution from Sambhava, the seven-year-old son of Vidhûra, chaplain to the King of Benares. In the second plaque—Sâma-Jat, 543—the incident depicted represents on the right Dukûla and his wife Parikâ, who are living as anchorites in the Himalaya region. They are blind, and their material wants are attended to by their son Suvannasâma. On the left appears Piliyakka, King of Benares, who while shooting at a deer carrying a pot of water for Suvannasâma, kills the latter.

Though the particular and varied stories illustrated are carried out in the conventional manner of the time, and consequently have a somewhat stereotyped appearance, the individuality of the artist is apparent throughout, so that they comprise specimens of the art of the period of a valuable order. At the same time they constitute reliable records, and extend definite incontrovertible records of the orthodox Buddhist iconography of the eleventh century. Two of these plaques are illustrated, with descriptions.

It is pleasing to note that the British government has placed the excavation and conservation of these relics in competent hands. A rule is that in restorations no additions must be made. However strong may be the presumption as to the appearance of a piece of work in its original state, the efforts of the restorers are confined to working with the pieces actually found, no modern additions being added.

The king's counselor is asked by his master to explain the nature of the Service of Truth. He cannot answer the question, but obtains the solution from a seven-year-old prodigy.

On the right a man and his wife are living as hermits. Their son, bringing them a jar of water on a deer's back, is accidentally killed by a hunter who aims at the deer.

ANCIENT BUDDHIST POTTERY DISCOVERED IN BURMA.

JOULE AND THE MECHANICAL EQUIVALENT OF HEAT.

By Prof. Florian Cajori.

Joule was the son of a wealthy brewer. In 1830 he saw the first trains which traveled between Liverpool and Manchester. One of the happy circumstances of his boyhood life was his connection with John Dalton and Dalton's laboratory containing effective home apparatus. His association with Dalton gave direction to his constructive genius. Joule's father fixed up a room for a chemical laboratory. Before the boy was of age he began experimentation in chemistry and electricity.

After laborious tests he succeeded in showing that the heat developed by the union of two chemical elements effected in a battery is the same as that developed by combustion, and that the heat has a definite equivalent in the electromotive force between these elements. He studied the relations between electrical, chemical, and mechanical effects, and was led to the great discovery of the mechanical equivalent of heat.

In a paper read before the British Association in 1843 he gave the number as 460 kilogrammeters. This was only a year after Mayer had published his first paper. Friends who recognized the physicist in the young brewer persuaded him to become a candidate for the professorship of natural philosophy at St. Andrews, Scotland, but his slight personal deformity was an objection in the eyes of one of the electors and he did not receive the appointment.

The early papers of Joule attracted little attention. His facts were so novel, so apparently heterodox, and the language in which they were conveyed so unfamiliar, that the older physicists permitted them to remain without due consideration. Faraday was then busy with his experimental researches. Graham was studying the diffusion of gases. Wheatstone, Whewell, Herschel, Forbes, Airy, were engrossed with problems of their own. Those who were first to applaud Joule a few years later were still pupils. William Thomson and Gabriel Stokes were at Cambridge; Rankine, a youth of 22, was studying engineering; Tait was a boy at school; Clerk Maxwell had just acquired the nickname of "Dafty" at Edinburgh Academy. In 1844 a paper of Joule, "On the Changes of Temperature produced by the Rarefaction and Condensation of Air,"

was rejected for publication by the Royal Society, but was printed in the Philosophical Magazine the year following.

In April, 1847, Joule gave a popular lecture in Manchester, delivering the first full and clear exposition in England of the universal conservation of that principle now called energy.

The local press would at first have nothing to do with it. One paper refused to give even a notice of it. The Manchester Courier, after long debate, published the address in full. In June, 1847, the subject was presented before the British Association meeting at Oxford. The chairman suggested that the author be brief. No discussion was invited. In a moment the section would have passed on to other matters without giving the new ideas any consideration, if a young man had not risen from his seat and by his intelligent observations created a lively interest in the new theory. The young man was William Thomson, now better known as Lord Kelvin. The result was that the paper caused a great sensation. Joule had attracted the attention of scientific men. After the meeting Joule and Thomson met and discussed the subject further and the latter obtained ideas he had never had before.

Joule experimented on the mechanical equivalent of heat for about forty years. By magneto-electric currents he got in 1843 the value of 460 kilogrammeters as the equivalent of the large French calorie. By the friction of water in tubes he obtained 424.9; by the compression of air, in 1845, 443.8; by the friction of water he obtained, in 1845, 488.3; in 1847, 428.9; in 1850, 423; in 1878, 423.—Popular Science Monthly.

THE NEXT APPARITION OF HALLEY'S COMET.*

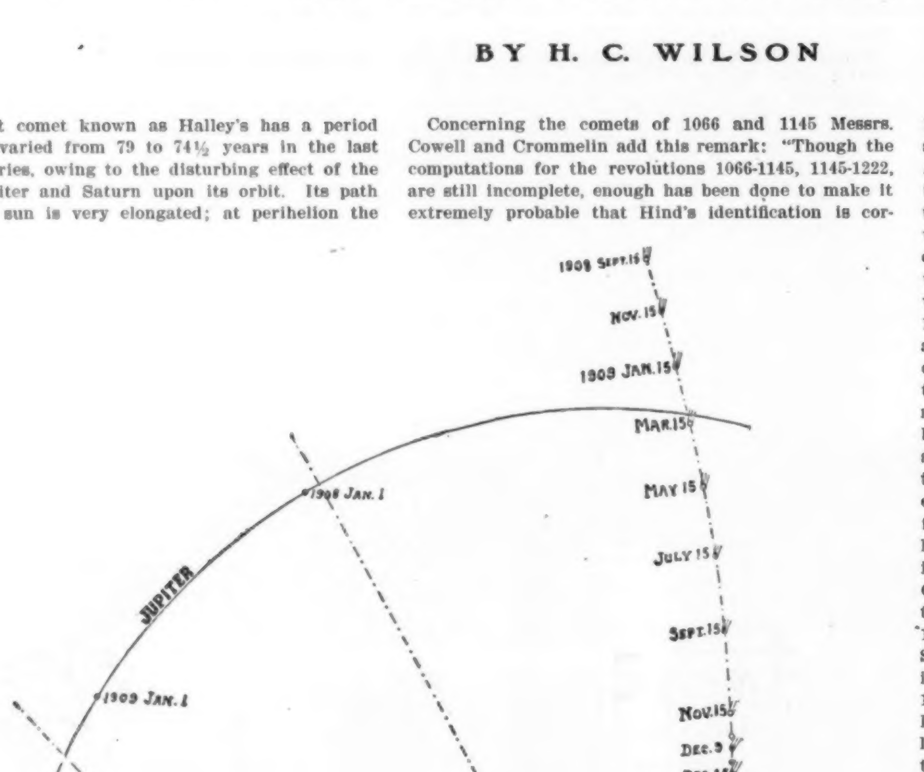
AN IMPORTANT ASTRONOMICAL EVENT.

BY H. C. WILSON

The great comet known as Halley's has a period which has varied from 79 to 74½ years in the last seven centuries, owing to the disturbing effect of the planets Jupiter and Saturn upon its orbit. Its path around the sun is very elongated; at perihelion the comet is nearer than Venus to the sun, while at aphelion it is farther off than Neptune, being then thirty-five times as far as the earth from the sun. The comet has been observed at each of its apparitions certainly as far back as the year 1222 A. D., and it is extremely probable that the identification of the great comets of 1145 and 1066 with Halley's comet is correct. Back of these the identifications are more or less vague, although two, those of the years 451 and 760 A. D., are fairly certain.

The French astronomer Pontécoulant carried the calculation of the perturbations of this comet back to 1531, and recently Messrs. Cowell and Crommelin of the Royal Observatory at Greenwich have extended the calculations back to 1222, and are now working on the revolutions 1066-1145 and 1145-1222. The result of these computations has been to prove that Hind's conjecture as to the identity of the comet of 1301 with Halley's is correct, but that his similar identification of the comet 1223 is erroneous, the perihelion of Halley's comet occurring in September, 1222, instead of July, 1223. "There was, however, a much more remarkable comet which appeared at the exact epoch of the calculation, and examination shows that the greater part of the statements made concerning it by contemporary writers are quite consistent with its being Halley's, so that the identity is placed beyond a reasonable doubt."

Concerning the comets of 1066 and 1145 Messrs. Cowell and Crommelin add this remark: "Though the computations for the revolutions 1066-1145, 1145-1222, are still incomplete, enough has been done to make it extremely probable that Hind's identification is correct in each case, though his elements of the apparition of 1066 clearly need modification. They differ more widely from the present elements than perturbations will account for. However, the positions are so vaguely recorded that large alterations in them are possible."



HALLEY'S COMET AND THE PLANETS IN 1910.

We have thus one great comet whose history has been traced back over eight centuries, and in that time it has come to perihelion eleven times and has not failed of being seen and recorded at a single apparition. It has at each return been visible to the naked eye and several times has been a splendid object, creating great interest and even terror among the people who saw it. The tail of the comet has varied very much in appearance at the different apparitions, owing to the different angles at which it was seen and the different background of dark sky or bright twilight against which it was projected. In 1066 it was a "famous object which created universal dread throughout Europe. In England it was looked upon as a presage of the success of the Norman invasion." In 1145, according to the Chinese records, on May 14 it had a tail 10 deg. long. In 1222 it is recorded that in the months of August and September a fine star of the first magnitude, with a large tail, appeared. According to the Chinese the tail was 30 cubits long and the comet remained in sight for two months. In 1301 and 1378 it was visible for six weeks. In 1456 it occupied a space nearly 70 deg. in length, and spread terror throughout Europe, being visible for a month. In 1531 and 1607 it does not appear to have been so conspicuous, the tail being recorded as only 7 deg. long. At the latter of these two apparitions Kepler described the comet as a star of the first magnitude, but so trifling was the tail that it was at first doubted whether it had any. Again in 1682 the comet attracted little attention except among astronomers; the tail was observed as 12 to 16 deg. long. This apparent waning of the comet led astronomers to fear that in 1759, its first predicted return, it might be so faint as not to be visible at all. However, the predictions of its course were so accurate that it was found, with the aid of small telescopes, by two observers three months before reaching perihelion. The tail did not become visible until after perihelion and when it should have been brightest was seen against bright twilight and so was not conspicuous, but in the southern hemisphere where the circumstances were more favorable it was visible to the naked eye and its length on one date was estimated at 47 deg. In 1835 it was visible to the naked eye during the whole of October, with a tail from 20 to 30 deg. long. The question now naturally arises, will the next return, in 1910, be under favorable or unfavorable circumstances? Shall we expect to see a great, magnificent comet as in 1456, or a comparatively insignificant object as in 1607, or will it be an ordinary big comet as in 1835? In order to aid in answering this question I have collected together the elements of the comet's orbit at the different apparitions which have been observed and have drawn the diagram which appears as the frontispiece of this number of Popular Astronomy (May, 1908).

APPROXIMATE ELEMENTS OF HALLEY'S COMET REDUCED TO THE EQUINOX OF 1910.

Perihelion passage.	Angle from ascending node to perihelion. Degrees.	Longitude of ascending node. Degrees.	Inclination of orbit to ecliptic. Degrees.	Perihelion distance.	Period years.
451 July 3...	108.5	53.3	16	0.60	...
760 June 11...	107.5	52.5	17	0.60	...
1066 Apr. 1...	...	...	...	...	...
1145 Apr. 29...	...	...	...	...	79.1
1222 Sept. 15...	105.6	51.6	16.5	0.67	77.4
1301 Oct. 22...	...	...	...	...	79.1
1378 Nov. 8...	107.77	54.67	17.9	0.584	77.0
1456 June 8...	104.82	50.08	17.62	0.581	77.7
1531 Aug. 25...	104.30	50.77	17.00	0.579	75.2
1607 Oct. 27...	107.25	52.66	17.14	-0.585	76.2
1682 Sept. 14...	109.26	54.35	17.76	0.583	74.9
1759 Mar. 12...	110.65	55.92	17.62	0.585	76.5
1835 Nov. 16...	110.64	56.19	17.76	0.586	76.7
1910 May 10...	111.54	57.18	17.78	0.59	74.5

Motion retrograde.

The diagram was prepared by the aid of ephemerides of the comet computed by Mr. F. E. Seagrave of Providence, R. I., and the elements differ slightly from those given in the last line of the table, but not enough to affect the shape of the diagram appreciably. Mr. Seagrave adopts May 10 for the date when the comet will be at perihelion. The computations of Messrs. Cowell and Crommelin point to an earlier date, probably about April 8 for perihelion passage. Comparing this with the dates in the table we see that this coincides very closely with that for the apparition in 1066 when the comet was a famous object.

According to the table, if we accept the records of 451 and 760 as being genuine records of Halley's comet, it has been at perihelion in all the months of the year except January, February, May, and December. The great displays appear to have been when the perihelion passage occurred in April, June, July, and November. The reasons for this will be plain to one who studies the diagram. The dotted curved line represents that portion of the comet's orbit which lies

* Popular Astronomy.

below the plane of the ecliptic; the smooth curve, including the dates February 12 to June 3, is above that plane. The inclination of the comet's orbit to the ecliptic being about 18 deg., the reader must think of that part of the diagram as being tilted out of the plane of the paper, revolved about the line of nodes through the angle 18 deg., so that the point marked May 2 would be about the highest point of the curve. Now imagine the earth to be moving in the plane of the paper and the comet in the tilted curve, and to pass the perihelion point (marked May 10 in the diagram) about April 1. It takes the comet about 40 days to pass from its perihelion out to the earth's distance from the sun, so that it would reach the nearest point to the earth's path about May 11 and during the first half of May the two bodies would be relatively close together; the nearest approach that could occur would be about May 4, when the comet, if it were directly below the earth, would be roughly 6,000,000 miles away. A few days' change in the date of perihelion would here produce a very great change in the comet's apparent course through the heavens. If perihelion should be a few days before the first of April, the comet would cross in front of the earth and so be seen in parts of the sky far from the sun when nearest the earth. In 1759 the passage occurred too early and in 1145 too late, if the date be correct, for the most magnificent effect.

For the perihelion passages in June and July it will be noticed that the comet is nearest the earth just after or close to the time of perihelion when the tail has its greatest development, and also when the comet is near its highest elevation above the ecliptic, so that even when in conjunction with the sun it is so far north as to be visible both evening and morning. In 1456 it was for a time circumpolar so that it could be seen above the northern horizon all night.

In August, September, and October the conditions are even better so far as position in the sky is concerned but the nearest approach to the earth occurs before the greatest development of the tail has been reached. For a November perihelion, especially in the latter part of the month, the favorable position of the comet in the sky during October largely offsets the lack of development of the tail, and so the apparition in 1835 was a favorable one. Had the comet passed the earth two weeks later than it did its distance on October 20 would have been only 15,000,000 miles and its tail might have appeared much larger than it did.

Now as to the 1910 apparition. The comet is now out between the orbits of Jupiter and Saturn. It will be within the distance of Jupiter's orbit after March 1, 1909. It is possible that some one with the aid of a great telescope or a photographic camera may catch sight of the expected visitor during the winter of 1908-09. We may begin to search for it as early as September, 1908, provided good ephemerides are at hand. Almost certainly it may be found by September or October, 1909. It will then be only a round nebula, whatever tail it has being almost directly behind it as seen from the earth. If the date of perihelion should be May 10, the comet will be lost behind the sun in the early part of April, reappearing in the morning sky about the first day of May. It should reach its greatest brilliancy in the last days of May but the morning dawn will prevent its having the most striking effect. It will pass between the earth and the sun about June 1 and there is a possibility then of the tail extending so far out over the earth that it may be very conspicuous in spite of the deep twilight in which the head of the comet must be observed. After June first the comet should be visible in the evening in the western sky, a more or less splendid object according as the effect of the lessening twilight or the increasing distance of the comet be the more important factor in changing its brilliancy.

If the date of perihelion should be April 8, as Messrs. Cowell and Crommelin predict, the circumstances may be quite different. We must then diminish all the dates on the diagram of the comet's path by thirty-two days. The comet will be lost in the twilight in March and reappear from the dawn in April. It will approach much closer to the earth as it passes between the earth and the sun in May, but will be much more nearly in line with the sun, so that at the time of conjunction we shall probably not be able to see it at all for two or three days. For a few days before this, i. e., about May 1, it should be a splendid morning comet and during the latter half of May it should be a fine object in the evening.

One fact which will strike the eye of the reader at once upon examining the table of elements of Halley's comet, which I have given above, is the great change in the period of the comet which may occur from one revolution to the next. It has in some cases amounted to more than two years, and it does not continue in the same direction in successive revolutions but sometimes increases and sometimes decreases the period. The longest revolution so far recorded is that of 1222-1301 and that of 1066-1145 is very near the same, 79 years and one month. The shortest round is the one now being accomplished, being a little less than 74 years six months. This extreme range of over four years in the period renders necessary the most careful and laborious calculation of the effects of the attraction of all the planets upon the comet, and it seems a marvel that the computers have come so near to predicting the exact date of perihelion at previous apparitions. In 1759 Clairaut and Lalande predicted a date twenty-three days too late, but Laplace has since shown that if the mass of Saturn had been accurately known at the time when the computations were made, the error of the final result would have been within nine days. The planets Uranus and Neptune were then unknown so that their influence was entirely neglected. In 1835 five computers obtained different dates ranging from October 31 to November 26. The actual perihelion occurred November 16 so that all were within sixteen days of the true date. Pontécoulant predicted November 14 and so was only two days in error. If the computers for 1910 can beat this record they will do well.

Halley's comet is sometimes spoken of as one of the Neptune family of comets. As a matter of fact Neptune, as the orbit of the comet is now situated, can have very little influence in disturbing it. The inclination of the comet's path is such that it nowhere approaches closer than 750,000,000 miles to Neptune's path. Both the nodes are near the other end of the orbit, near the paths of earth, Venus, and Mars and these little planets have more influence upon the comet's motion than can Neptune have. It is difficult to see therefore how Neptune can have been instrumental in capturing this comet. It is true there is some indication of a shift of the line of nodes around the orbit, and in long ages past the descending node may have been in the vicinity of Neptune; in any case the time is very remote.

LIVING CELLS WITHOUT NUCLEI.

By DR. VLADISLAV RUZICKA.

IT has hitherto been assumed that every living cell consists of a nucleus surrounded by a mass of cytoplasm of different chemical composition (Fig. 1) and it is now universally believed that every living organism consists of a cell or a number of cells. The cell, therefore, is regarded as a morphological element, or the simplest form in which living matter is capable of independent existence.

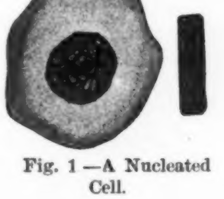


Fig. 1.—A Nucleated Cell.

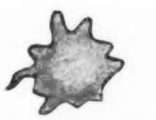


Fig. 2.—Non-Nucleated Parasite Found in Eggs of Certain Worms.

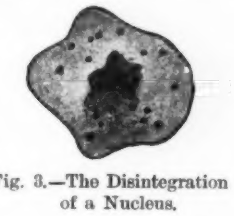


Fig. 3.—The Disintegration of a Nucleus.

But a cell is by no means a simple thing. Even apart from the obvious inference of complexity of physical and chemical structure from the multiplicity of external relations and actions, the complex character of the cell is shown in its division into two parts which differ in chemical composition and in function. This complexity of the cell will remain a stumbling block in the way of the theory of the evolution of life from lifeless matter so long as no living organism simpler than the cell is known. This fact has long been recognized and for a time it was believed that certain cells, called cytodes, consisted entirely of cytoplasm and were destitute of nuclei. Improvements in the technique of the microscope and progress in the study of the lowest organisms, however, have proved this belief to have been erroneous and confirmed the theory of the non-existence of non-nucleated organisms.

But in the establishment of this doctrine two groups of organisms, in which no nuclei could be found by unprejudiced observers, were passed over. These are bacteria and the red blood corpuscles of mammals. The blood corpuscles were assumed to be modified cells and attempts were made to prove that bacteria were nucleated like ordinary cells.

Certain recently published researches in which the newest and most varied methods of investigation were employed give a better insight into the structure of bacteria and red blood corpuscles. These researches were based on the fact that the nucleus of a cell is insoluble and the enveloping cell substance, or cytoplasm, is soluble in artificial gastric juice. Hence the presence or absence of a nucleus, or a nuclear matter, was determined by the behavior of the organism toward artificial gastric juice.

By applying this test to bacteria (1) and the red blood corpuscles of mammals (2) I have succeeded in proving that both of these groups of organisms consist *entirely of nuclear matter* and McAllum has reached the same conclusion with respect to blue algæ and sulphur bacteria (3). Hence it appears that these organisms, in which no nuclei can be detected by the microscope, are non-nucleated only in the sense that they *are* nuclei, not surrounded by cytoplasm. But they are certainly not cells in the accepted meaning of the word. On the other hand, Schewjakoff (4) has described an organism (*Achromatium oxaliferum*) which he regards as consisting entirely of cytoplasm, and Vejdovsky (5) has made a similar assertion in regard to an amœboid parasite which he discovered in the eggs of certain worms (Fig. 2). But in neither of these cases was the chemical test employed to determine the character of the protoplasm under observation, so that we have yet no satisfactory proof of the independent existence of permanently non-nucleated cytoplasm.

Hence, in seeking simpler antecedents of the complete cell we are led to a conclusion diametrically opposite to the view hitherto held. The cytodes, in Haeckel's sense of the word, are not organisms destitute of nuclei, but are organisms destitute of cytoplasm, that is, naked nuclei.

It would be quite unjustifiable, however, to deny *a priori*, the possibility of the independent existence of non-nucleated cytoplasm. We have reason to believe that protozoa, leucocytes or white blood corpuscles and the eggs of low animal organisms can dispense with nuclei, temporarily at least, without suffering injury. In certain stages of the life of these organisms the nucleus is broken up into granules, the *chromidia* of Hertwig (Fig. 3), which are not merely unaltered fragments of the nucleus, but are chemically more nearly akin to cytoplasm, as I have proved (6). At the moment of disintegration of the nucleus, therefore, the organism consists wholly of non-nucleated cytoplasm. Moreover, the behavior of non-nucleated fragments obtained by artificial division of infusoria and similar unicellular organisms indicates that the interaction between nucleus and cytoplasm is not absolutely necessary for the preservation of life, for these non-nucleated fragments can be kept alive for weeks.

The researches quoted above not only prove the existence of organisms which are in some sort less complex than the complete nucleated cell, but they point to new conceptions of the importance of the nucleus and its relations to the cell substance or cytoplasm.

1. Archiv fuer Hygiene, 47, 1903; 51, 1904.
2. Archiv fuer Mikroskopische Anatomie, 67, 1905.
3. University of Toronto Studies, 1900.
4. Nat. hist. med. Verein in Heidelberg, 1893.
5. Boehmische Gesellschaft der Wissenschaften, 1904.
6. Biolog. Zentralblatt, 27, 1907.

—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Umschau.

PURIFICATION AND DISINFECTION OF WATER.

THE various methods of filtration, which have been devised for the removal of bacteria from water, having proven ineffectual, search has been made for chemical germicides which are not injurious to health. Ozone nearly satisfies these requirements but the process of applying it requires a supply of electricity and costly apparatus.

Professors Paterno and Cingolani, of the University of Rome, recommend a process which is both cheap and easy of application. It consists merely of the addition of 2 parts of silver fluoride or *tacchiol* to each million parts of water. The silver fluoride reacts with the calcium chloride which is naturally present in the water, forming silver chloride and calcium fluoride, both of which are insoluble. The water becomes slightly turbid, but decantation or coarse filtration renders it perfectly potable. The process costs only a few centimes (5 centimes equal 1 cent) for 1,000 liters (264 gallons) of water and is very effective. Comparative tests have been made of water containing sewage or cultures of bacteria, silver fluoride having been added to some specimens but not to the others. The latter were found to contain from 4,000 to 5,000 colonies of cholera vibriones, from 4,000 to 6,000 colonies of Eberth's bacillus of typhoid, and from 5,000 to 6,000 colonies of the *Bacterium coli* of dysentery, per cubic centimeter, while the treated specimens, a few days after the addition of the silver fluoride, were entirely free from bacteria.

The only iron foundry in Colombia, South America, is at Bogota. It is known as La Paradera, and is operated on a small scale, native ores being smelted, the iron being subsequently re-melted for casting purposes. There are several commercial iron deposits in the interior of the country, and one ore body located near the coast of the Caribbean Sea is now being drilled by American engineers.

ELECTRICAL NOTES.

In order to obtain an inexpensive thermo-electric couple for measuring temperatures of molten metals, Mr. W. H. Bristol employs for the two elements different forms, kinds, or grades of carbon or graphite. These elements are capable of withstanding extreme temperatures and they do not appreciably alloy with most molten metals. In a patent issued April 21, it is stated that a particularly satisfactory couple can be made by using as one element pure carbon or graphite and combining from 15 to 20 per cent Bavarian clay with carbon or graphite to form the other element.

A convenient form of high resistance is made by spreading upon an insulating surface a mixture of lampblack and a transparent lacquer, an American commercial product called Zapon L. The conductivity of the films may be easily regulated either in mixing or in laying on the mixture, and the resistance may be made in forms varying from a few thousand ohms to many megohms. When the lacquer is dry there is left a film of pyroxylin, which forms an elastic covering not subject to ordinary changes of temperature, which does not crack or evaporate, and is a good insulator. Resistances made with this mixture diminish in value rapidly at first, but the variation grows much less with time. A process of baking might bring the films to a steady state at once. The resistances increase somewhat with increase of humidity, but this change can be avoided by keeping the films in sealed tubes.

Great interest has been aroused in European electrical centers by a new insulating material for electric cables, some severe tests of which were recently carried out in the vicinity of London. The insulating material, which is called "liconite," is the invention of Mr. Ali Cohen, of Singapore, and is a bituminous compound having high resisting qualities, prepared by a secret process. It has all the advantages of rubber and gutta percha, while its cost of manufacture is considerably less, and what is far more important from the electrical point of view, it is not affected by water or electrolysis and is capable of withstanding exceedingly high tension. In the tests that were carried out a leadless paper copper cable 600 feet in length and of 0.25 square inch section was insulated with fifty-six layers of liconite paper, then covered with two layers of liconite tape and one layer of Hessian tape, the resistance being about 10 megohms per mile. This section was immersed in water for twelve days and was then flashed with 32,000 volts for five minutes without breaking down. A piece six feet in length was then cut from the cable and bent round an 18-inch drum three times in each direction. A high-tension current was then applied and it withstood the test until a pressure of 70,000 volts was reached, when it broke down. Another similar six-foot length was cut off the first cable, bent round a drum as in the previous instance, and immersed in water with the ends bare. This withstood the test until 70,000 volts was attained. Numerous other severe tests were applied to the material from which it emerged with great success, showing its utility for all the purposes to which India rubber and gutta percha covered and lead-sheathed cables are applied.

In a paper recently read before the Royal Sanitary Institute of London by Dr. Samuel Rideal, the results and conclusions derived from a number of interesting experiments are given. The investigations were carried out to determine the respective physiological effects due to lighting by gas and by electricity. The main conclusions may be summed up as follows: 1. Owing to the better ventilation obtained by gas, the products of combustion are not found in the air in the proportion which might be expected, the temperature and humidity in an occupied room being no greater than when the room is lit with electric light. 2. Carbonic acid has not the injurious effect which was formerly attributed to it, but considerable rises in the temperature and moisture content of a room, from whatever source, do have a prejudicial effect upon the well-being of the occupants. Even under adverse conditions of ventilation, purposely created for this inquiry, neither the temperature nor percentage of moisture in the room reached a point at which any such effect could be detected by any of the recognized physiological tests. 3. It has been established that the products, viz., heat, carbonic acid, and moisture, so far as they modify the health of the occupants of a room, are derived from the inmates more than from the illuminant, and that a room of moderate size can be efficiently lighted by gas without sensibly affecting the amount of these three factors. 4. While undoubtedly it is important to insure adequate ventilation in domestic rooms, this, with present methods of construction, is better insured the smaller the room. 5. The medical conclusions are in accord with those arrived at from the chemical and physical data, and also demonstrate that the choice between the two systems of lighting does not depend upon hygienic considerations.

ENGINEERING NOTES.

During 1907 one firm in Philadelphia produced 2,663 locomotives; this is the largest output in the history of the firm. They employed an average number per week of 18,655 men. The total output includes 2,371 steam locomotives and 292 electric locomotives. Of the steam locomotives forty were of the Mallet type, which comprises two sets of driving wheels, cylinders and valve gear under one large boiler. Two of these locomotives are about equivalent to three ordinary locomotives.

Dredging for gold is steadily increasing in California. Estimates of the yield of gold by this method in 1906 give a production of $6,000,000, while the output of the following year is placed at $7,000,000. In 1902 the production was only $867,000, which was doubled the next year, and has increased steadily since. Improvements in the methods and machinery are important factors in the rapid development of this class of mining, and new placer beds are being discovered, which are quickly followed by an increase of the number of dredges already at work.

A portable blacksmith shop has been found very convenient and economical in the maintenance of way department of the Missouri Pacific Railway. It consists of two box cars, one for sleeping accommodations of the blacksmith and his helper, and the other for his shop. All necessary tools and duplicate parts are carried for repairing switches, frogs, hand cars, switch stands and similar railroad appurtenances. Frogs are taken from the track, repaired, and replaced where traffic is light, by protecting the point by flags, and where traffic is heavy, a duplicate frog is put in. The portable shop saves shipping the tools and equipment needing repairs, thus reducing cost and avoiding delay. It has been found that one day, according to the Railroad Gazette, is sufficient for cleaning up the repairs on an ordinary section.

For many months a big well-drilling machine had been boring into the dry ground of the Black Hills region of South Dakota alongside the track of the Burlington railroad at Edgemont. Down went the drill, until the native onlookers wondered whether the railroad company had fixed no limit to the bore, and was simply "going it blind," indefinitely. The company's intention was very definite, indeed. Its officials had been informed by a geologist of the United States Geological Survey that a good supply of water would be found in a certain stratum of rock that lay at a depth of about 3,000 feet. This geologist had made a study of the surface outcrops of the rocks of the region, and had based his prediction on that study. And, having faith in the prophecy, the company determined to drill to that depth. It was not necessary, however, to bore quite to the depth of 3,000 feet, for when the drill had gone down 2,980 feet water gushed out at the rate of 350 gallons a minute, and the faith reposed in the judgment of the geologist was justified. This water supply fills a need which is so urgent that if anything should happen to destroy this well the railroad company would not hesitate to bore its counterpart.—Iron Age.

Mr. H. W. Woodall, in a paper on Continuous Carbonization in Vertical Retorts, recently read before the Institution of Gas Engineers, pointed out that the gas industry was at present entering upon a most interesting period of its history. Several new methods of carbonizing were being introduced, each possessing special features and showing promise of improvement over existing methods. Among these was a process of continuous carbonization in vertical retorts, which constituted a radical departure from existing methods. A plant had been installed at Bournemouth, England, and had been in continuous and satisfactory operation since October last. The history of what had been achieved might be summarized by the statement that continuous carbonization was more a question of mechanics than retorting, and, starting with a simple form of apparatus, mechanical devices had been added until the desired result was attained. An improved method of discharging was one of the latest improvements. The result had been: coal carbonized, 1,731 tons; gas made, 22,832,000 cubic feet, equal to 13,190 cubic feet per ton of coal, with an illuminating power of 14.1 candles. Somerset coal could be carbonized without trouble. Tests at Nine Elms showed 12,423 cubic feet of gas per ton of coal, with an illuminating power of 15.82 candles. The latest results at the Poole vertical retort gave over 14,000 cubic feet of gas per ton. An analysis of Nine Elms gas showed that the gas was for all practical purposes pure coal gas, there being only 7.41 per cent of carbon monoxide, with methane at 35.05, hydrogen at 45.85, and nitrogen at 6.32 per cent. Retort house wages at Bourne Valley (Bournemouth) worked out at 1d. per 1,000 cubic feet. The main advantages of continuous carbonization were increased make of gas, improved yield of tar and ammonia, utilization of heat at present wasted for the production of water gas if desired, gas free from naphthalene, and relatively better coke.

TRADE NOTES AND FORMULÆ.

Galazyme Kumys.—To 75 parts of skimmed milk add a solution of 3 parts of cane sugar and 2 of water, with fresh compressed yeast and keep deg. F. until fermentation sets in, then add anoth parts of skimmed cow's milk and 5 parts of mil gar, and fill it into bottles.

Creoline (according to Guming).—Basic subst crude carbolic acid or the oil of creosote of comm is distilled in an iron retort and the portion p over at a temperature of 387 deg. to 540 deg. F. densed for itself. This is allowed to stand a few in a cool place until the napthaline subsides as fa possible and can be separated by filtration. The re ant oil is shaken up with 5 per cent soda lye water subsequently treated with it is not colored barely colored by dilute chloride of iron solution remove the basic substance the oil is then agit with sulphuric acid of 5 to 10 per cent. The foll ing serves as a reagent: Neutralization is effected means of soda lye, which must not cause any clouding of the fluid. In this oil 30 per cent of crushed rosin is dissolved under application of as much caustic soda is added as will be equal to per cent in sodium hydroxide of the weight of rosin, after it has previously been dissolved in a water; finally 5 per cent of 92 per cent alcohol added and the mixture agitated and heated.

Belt Dressing.—The following is given in Te Rundschau, in response to an inquiry. As materi for the manufacture of belt dressing, we may enum ate tallow, wax, paraffine, cod liver oil and castor These ingredients must be as free as possible fr acid. To deprive tallow and train oil, which usu contain free acid, of acid, we stir into the melted low about 5 per cent of soda lye, of about 30 deg. After about a quarter of an hour, add about 10 cent of common salt solution, of 24 deg. Bé; stir it and allow to cool. The free acid combines with lye, added to form a soap, which is separated by salt solution. It is allowed to cool and the cake fat lifted off. By combining the above menti substances, we obtain, according to their properti a soft or hard preparation. We may choose from following combinations: 10 parts tallow, 7 par and 3 parts of train oil. The tallow is reduced after it is completely dissolved, add the train While it is still fluid pour it into sticks. The are best made from tinned steel plate.

Plastic Carbon for Filtration.—Two mixtures: 60 parts of coke, 20 parts of spodium (animal ch coal), 10 parts of wood charcoal and 10 parts of clay; (b) 10 parts of coke, 30 parts of spodium, parts of wood charcoal, 40 parts of asbestos, powdered and sifted, then intimately mixed tog and then so worked up with molasses (syrup) that plastic dough can be kneaded. The kneaded mass formed into disks or cylinders, allowed to dry fo short time at moderate heat and then, without cess of air, placed in the carefully heated mu After gradual cooling, the burned masses are pl in strongly diluted hydrochloric acid, to extract soluble ash salts and replace the sulphide of iro they are then thoroughly washed in running wat dried and again heated in a carefully closed muffle a dark red heat. The finished mass is now given desired shape on the lathe, saucers, cups and funn being formed. If an inclosed hollow vessel is to formed with this carbon, the two saucer-shaped p tions are cemented together in the following ma ner: Turnings of the washed mass are mixed with pure syrup produced by dissolving refined su in half its weight of water. With this paste the ed of the two halves that fit one another are smear all joints carefully spread with it and the holl filter, thus cemented, after drying is placed in a clo muffle and burned at a moderate red heat.

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